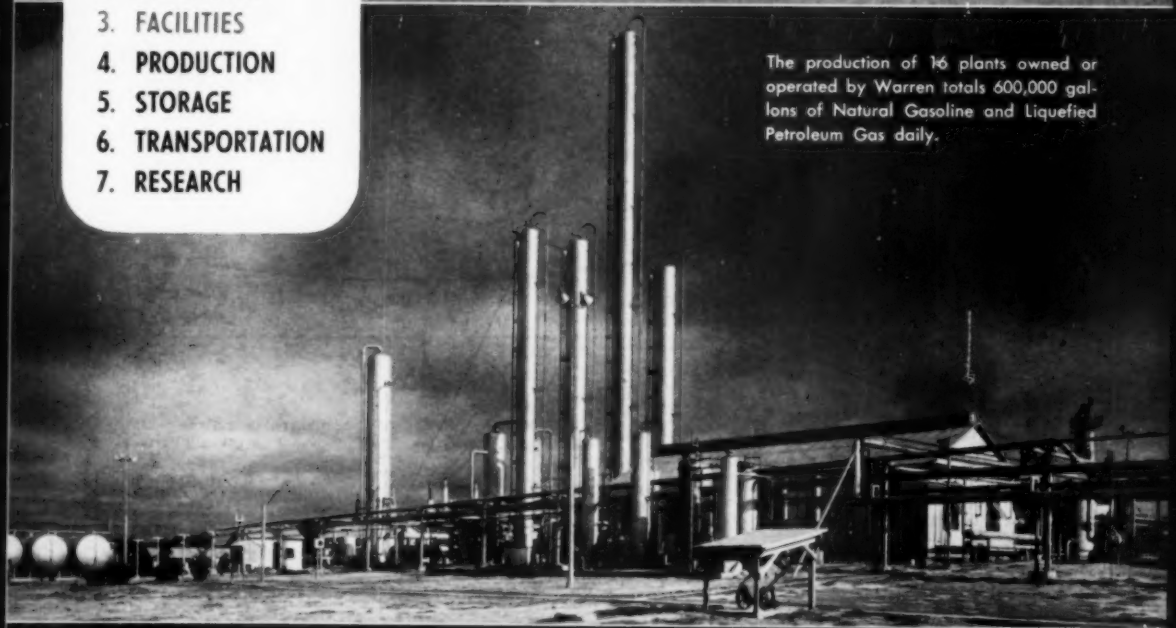
PETROLEUM REFINER

7 Reasons WHY IT'S WARREN

1. PERSONNEL
2. EXPERIENCE
3. FACILITIES
4. PRODUCTION
5. STORAGE
6. TRANSPORTATION
7. RESEARCH



The production of 16 plants owned or operated by Warren totals 600,000 gallons of Natural Gasoline and Liquefied Petroleum Gas daily.

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Producers, Manufacturers, Exporters and Marketers

Export Terminals: Corpus Christi, Port Arthur, Baytown, Texas City, and Norsworthy, Houston, Texas.

TULSA 2, OKLAHOMA CABLE ADDRESSES: Stavolene, Warren

WARREN'S MADILL, OKLAHOMA PLANT

Crude Oil, Natural Gasoline and Liquefied Petroleum Products

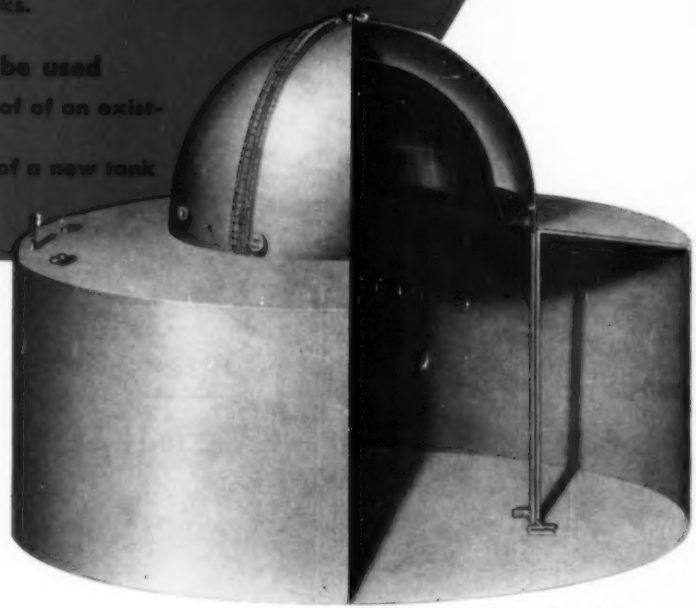
Now there is another way to stop evaporation losses—

use the new Horton VAPORDOME ROOF

. . . provides an expansible vapor space for one or more fixed-roof tanks.

designed to be used

- as a new roof of an existing tank
- as the roof of a new tank



Patent applied for

THE Horton Vapordome Roof is a brand new addition to the Horton line of vapor-saving structures. It is designed for installation on flat-bottomed tanks, as shown in the cutaway view at the right, and can be used to prevent evaporation loss of volatile products stored in a single tank, or in a group of interconnected tanks. The dome of the roof contains a flexible hemispherical membrane that "breathes"—allowing the air-vapor mixture above the stored liquid to expand and contract when the temperature changes without being vented and lost.

In operation, the Vapordome Roof is similar to the Vaporsphere. The Vapordome Roof can, however, be installed more economically as the roof of a new tank, when re-roofing an existing tank, or when there is no ground space for a Vaporsphere. Write our nearest office for complete engineering data.

Advantages...

- Easily installed as roof of new tank or roof of existing tank. Needs no round space.
- Operates dependably in any climate. All moving parts are enclosed.
- Operates without cost, aside from ordinary maintenance.
- Operates at low pressure—interconnected tanks do not require reinforcement.
- Tanks can be added to or cut out of vapor-saving system without taking Vapordome out of service.
- Extremely low fire hazard from either internal or external sources.

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PETROLEUM REFINER

Specialized for Refining, Natural Gasoline and Petrochemical Engineering, Operation and Management

R. L. DUDLEY, President, Publisher A. L. BURNS, General Manager

VOLUME 28, NO. 3

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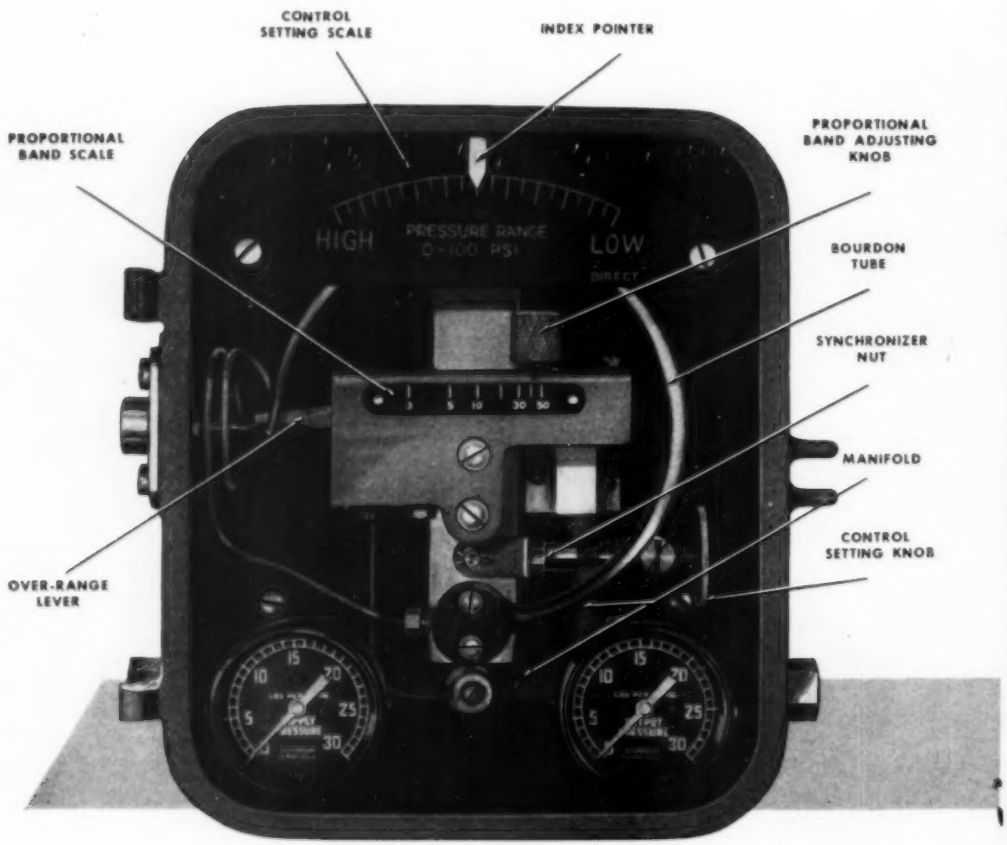
Providing Precise Response and Proportional Control at Moderate Cost

These controllers are designed for many industrial applications requiring accurate control where more expensive instruments are not warranted.

Applications include, among many others, pump governors, steam pressure reducing stations, gas well pressure reduction, etc., requiring small to intermediate proportional band.

The case is rugged and suitable for outdoor service; it is so designed that it may be mounted on the valve (on integral pad or by means of a U-clamp) or, *if the occasion arises, it may be removed from the valve and mounted on a wall.* A flush type case is also available for panel mounting.



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1. Pneumatic proportionality accomplished with feed-back bellows and cantilever leaf spring.
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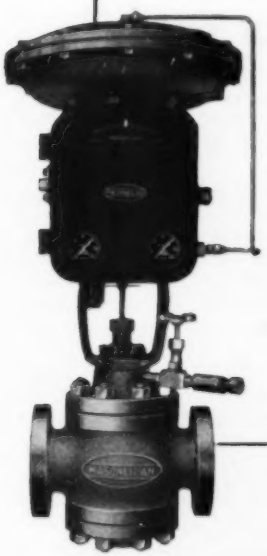
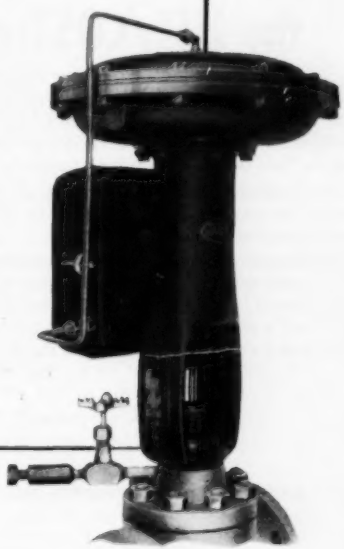
3. Large powerful bourdon tube for greater response and control performance.
4. Adjustable proportional band between 3% and 50%.
5. Wide selection of pressure ranges.
6. Cases for valve or wall mounting; also flush panel mounting
7. Ease and accessibility of adjustments.
8. For applications involving corrosive conditions, controlled pressure connection, tubing to bourdon tube and entire bourdon tube assembly, made of Type 316 Stainless Steel, are available.
9. Unit construction (proportional mechanism, nozzle block, etc.) and manifold.
10. Control action reversible with either bourdon or bellows.
11. Manifold construction prevents transmission of any possible case distortion to control mechanism.
12. Set point indication.





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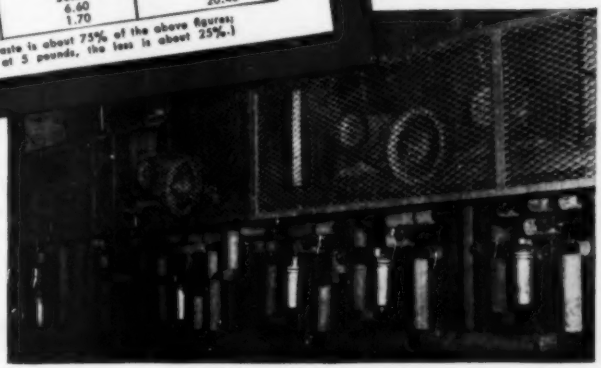
PETROLEUM REFINER, published every month. Entered as second class mail matter June 16, 1923, at the post office at Houston, Texas, under act of March 3, 1879.

SMALL STEAM LEAKS

Showing cost of various sized steam leaks at 100 pound pressure. (Assuming steam costs 50 cents per 1000 lbs.)

Size of Orifice	Lb. Steam Wasted Per Month	Total Cost Per Month	Total Cost Per Year
1/2"	835,000	$417.50	$5,010.00
3/8"	470,000	235.00	2,820.00
1/4"	210,000	105.00	1,260.00
1/8"	52,500	26.25	315.00
1/16"	13,200	6.60	79.20
1/32"	3,400	1.70	20.40

(For steam at 50 pounds pressure, the waste is about 75% of the above figures; at 20 pounds, it is about 50%; and at 5 pounds, the loss is about 25%.)

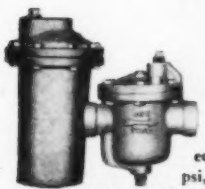


TYPICAL FUEL SAVINGS SECURED WITH ARMSTRONG TRAPS

20% FUEL SAVINGS after trapping all heating coils individually. — Norton Greenhouses, St. Paul, Minn.

33-1/3% REDUCTION IN ANNUAL COAL BILL after installing Armstrong traps on cooking vats. — Ralph L. Smith Lumber Co., North Kansas City, Mo.

3,728 GALLONS OF FUEL OIL SAVED in one year after replacing old traps with Armstrongs on kettles, low pressure heating system and cream beaters. — Mary Lincoln Candies, Buffalo, N. Y.



STEAM SAVERS:

For trapping heating systems and process equipment from 1 to 250 psi, Armstrong Traps are available in side inlet—side outlet or bottom inlet—top outlet body styles. These compact, dependable traps provide more actual hot condensate capacity per dollar of trap investment than any other traps on the market. For selection data, capacities and prices SEND FOR the 36-page ARMSTRONG STEAM TRAP BOOK.

CHECK YOUR STEAM TRAPS *now!*

The chart above shows that a "little" steam leak can cost a lot—and a hundred or a thousand little leaks cost a lot more! No plant can afford the luxury of leaky steam traps. It costs far more to keep them than it does to replace them with modern Armstrong Inverted Bucket Steam Traps. Armstrong Traps won't leak steam because:

1. The valve and seat are ground and lapped to a precision, steam-tight fit.
2. The valve is water-sealed at all times.
3. Both the valve and seat are made of chrome steel, heat treated for long life and corrosion and erosion resistance.

With today's high fuel and operating costs Armstrong traps are priced lower in proportion to the savings they can effect than at any time in their history. Let your nearby Armstrong Representative help you select the traps you need or write direct to the factory.

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ARMSTRONG *Inverted Bucket* **STEAM TRAPS**

Factory Representatives in 48 Key Cities... Traps Stocked at 147 Points

PETROLEUM EQUIPMENT

"Buying Guide"

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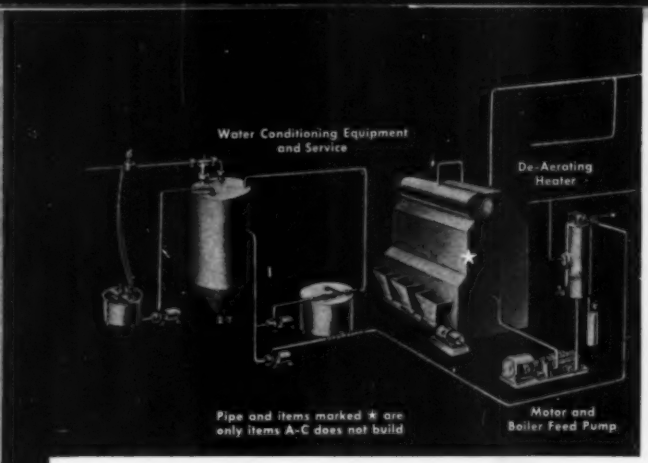
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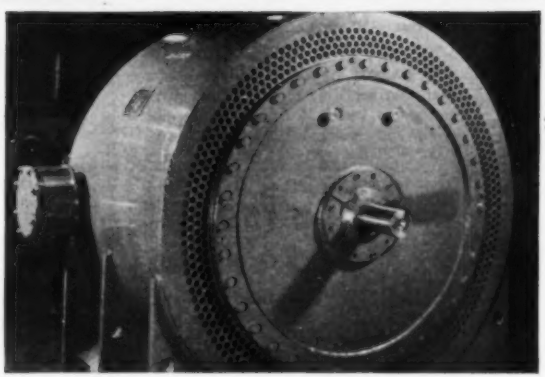

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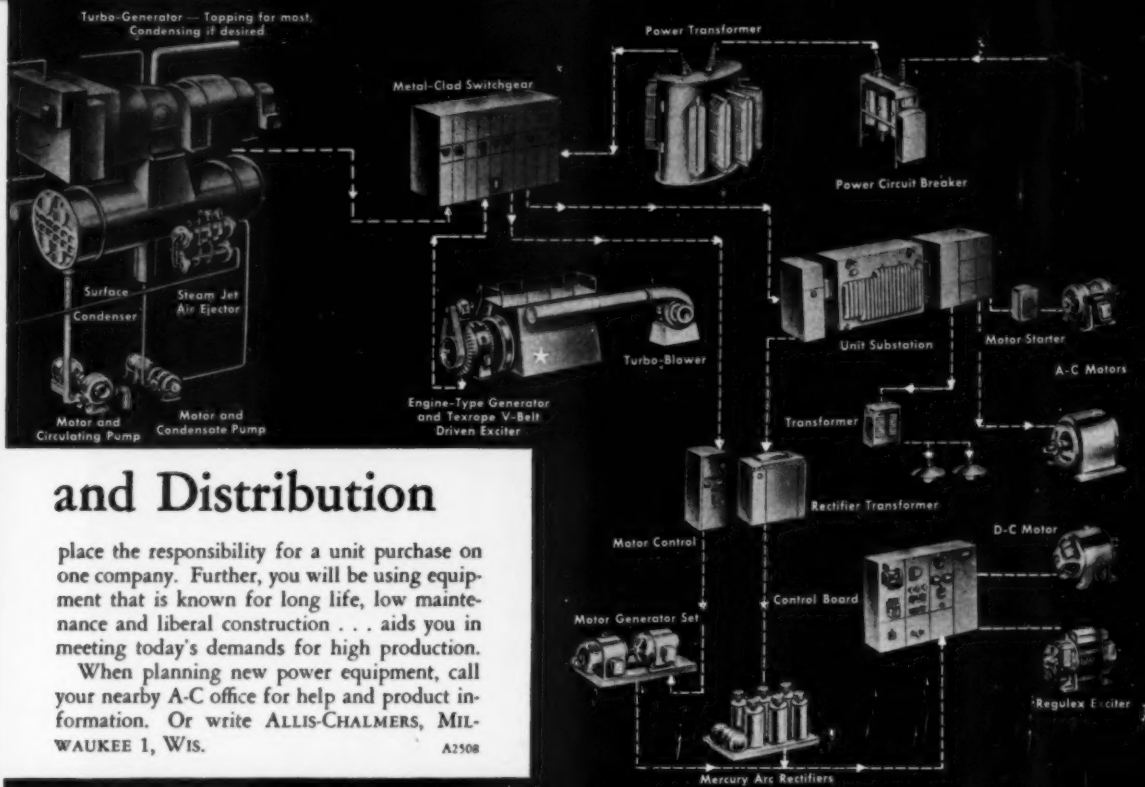

and Distribution

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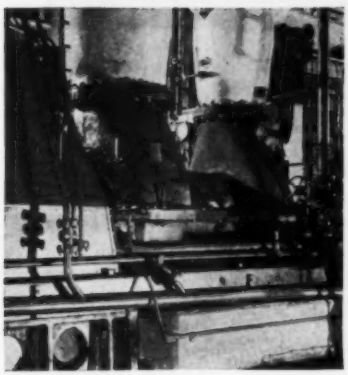

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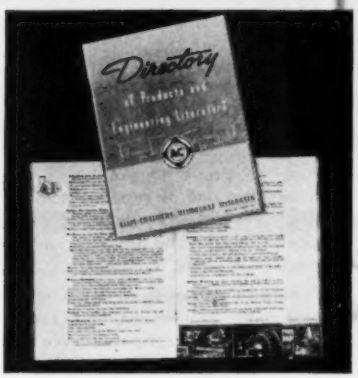
FOR PUMPING GASOLINE, WATER and other liquids, A-C can supply pumps in many types and sizes. Included is the Self-Priming unit, popular for loading and unloading tank cars, barges, etc. because it maintains pumping action even when slugs of air or gas are admitted.



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and General Machinery for the Petroleum Industry

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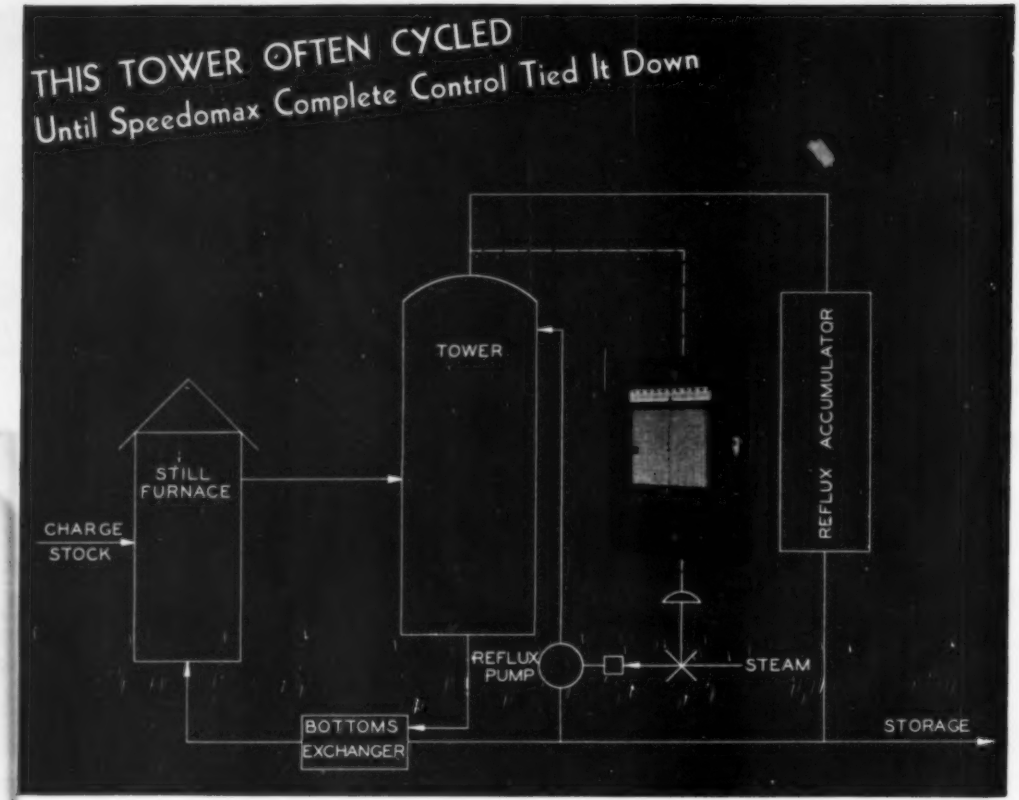
Until Speedomax Complete Control Tied It Down



A certain refinery was plagued by occasional cycling in a group of seven towers used for gasoline production. Just a few minutes of off-temperature operation, on only one of the seven units, frequently cost the profit margin between a tankful of premium and one of regular gasoline. Company engineers simply accepted cycling as part of this particular set-up because no available temperature controller could handle this job.

When the new Speedomax *complete* Pneumatic Control was announced, however, the engineering department investigated. We explained our new product's features; especially its truly-stabilized rate action. The refinery men saw that this type of action ought to stop cycling. We told them it would, and had already done so in other plants. So, they decided to try it for themselves.

One of the first tests of the new control came when the operator was told to step the tower up from 440F to 455F. The operator, playing safe, started by shifting the control setter just five degrees. The temperature rose promptly; settled at the new figure. Another step—and a third—with the same results—put the unit at 455F without loss of a minute's time and with no cycling whatsoever. The premium grade was attained for all production.

Naturally, more Speedomax complete Pneumatic Controls have gone to that plant. They are showing benefits on other processes—benefits due to such merits as stable control point and bumpless transfer from manual to automatic regulation. Today the plant uses over thirty of these equipments as part of their still-expanding instrumentation program.

Complete details of Speedomax Pneumatic Control are in Catalog ND4B. Write for it today. Or, if you prefer, an L&N Field Engineer will be glad to call on request. Leeds & Northrup Company, 4923 Stenton Avenue, Philadelphia 44, Pa.

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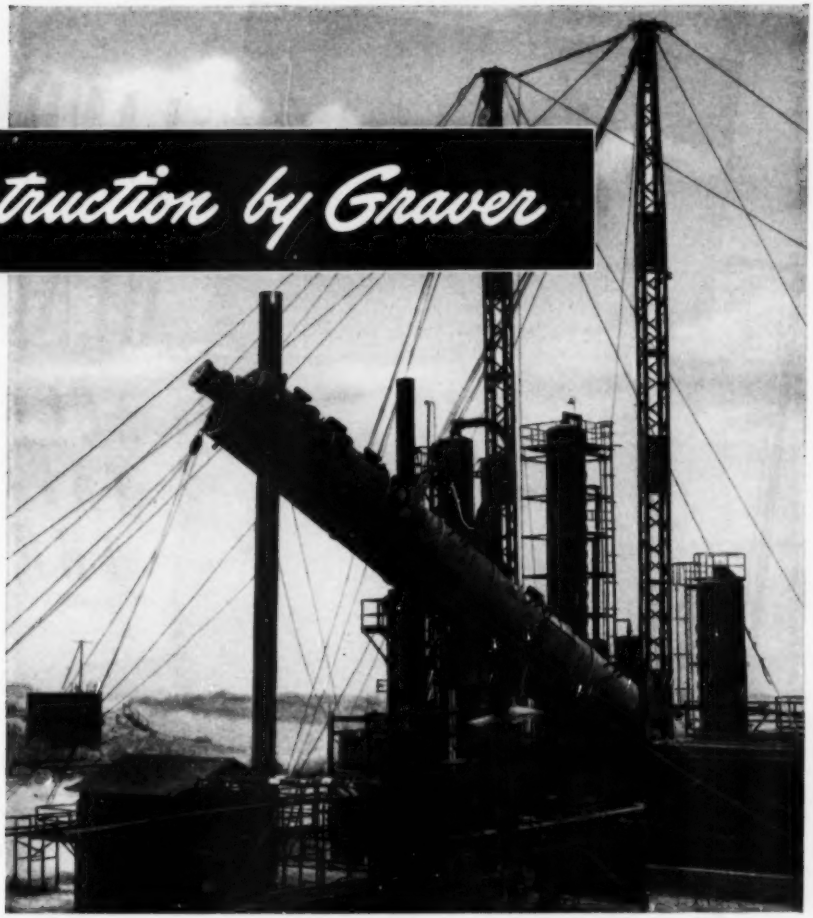

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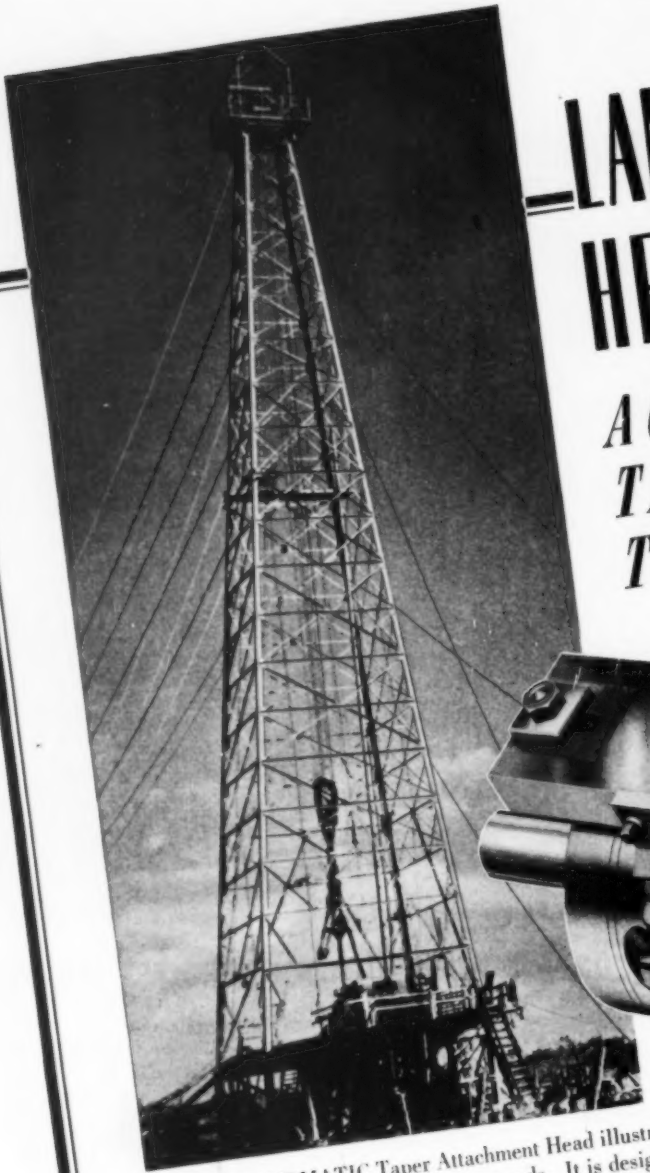
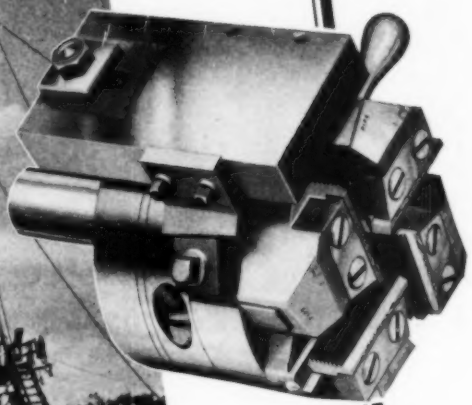
LANDMATIC HEADS *for* ACCURATE TAPERED THREADS

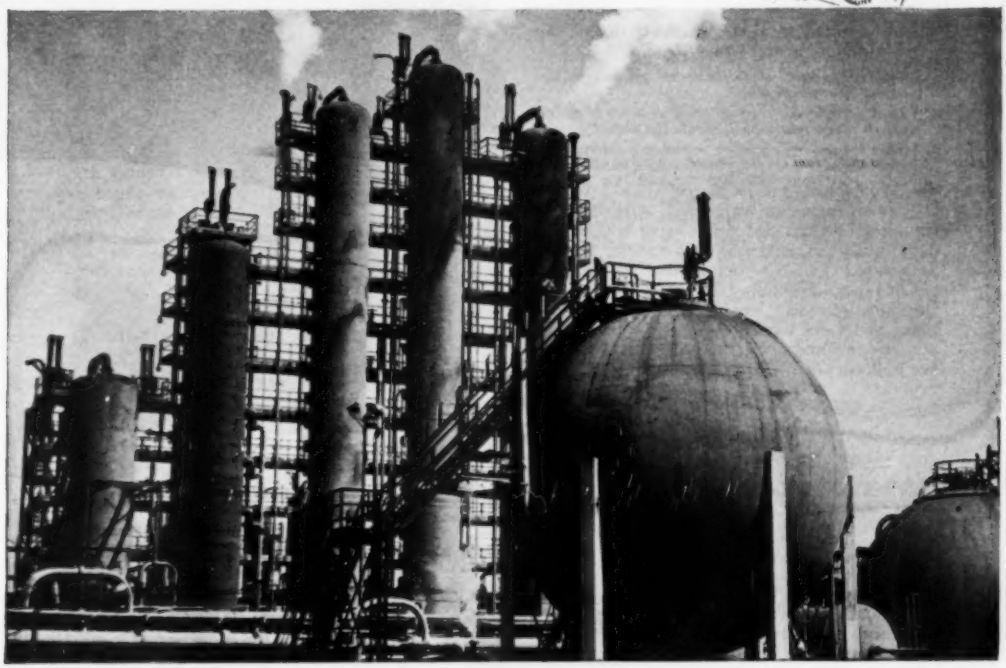




● The 2" LANDMATIC Taper Attachment Head illustrated is widely used in the production of oil tubular goods. It is designed primarily to cut taper threads to exacting A.P.I. standards. The Taper Attachment by limiting cutting action to the throat section of the chaser reduces chaser wear and increases thread accuracy. *Write for Bulletin F-90.*

LANDIS MACHINE CO.
WAYNESBORO, PA., U. S. A.

IN REFINERY OPERATIONS, ENDURO Stainless and Heat-Resisting Steel daily is proving its value by providing dependable, uninterrupted service where ordinary materials fail. Its many applications include cracking stills and tubes, condensers and heat exchangers, still lining, hot oil lines, sludge tanks, swing lines, tanks, valves, bubble caps and trays.



. . . AND NOW FOR LOWER MAINTENANCE COSTS

Equipment made of Republic ENDURO Stainless and Heat-Resisting Steels offers many maintenance advantages. *Faster, easier cleaning . . . fewer production interruptions . . . substantially lengthened equipment life . . .* all result from the adoption of stainless steel for vital processing equipment.

ENDURO is not an ordinary metal. It is unusually strong and tough, and highly resistant to extreme heat . . . retaining its exceptional physical properties at high temperatures. It effectively resists the damaging effects of hot gases, rust and corrosion, too. These qualities, plus its easy-to-clean surfaces, make ENDURO a match for the most exacting refinery and chemical requirements.

There are many ENDURO analyses, each designed to meet specific application needs. Talk with your equipment manufacturer or write for more information.

REPUBLIC STEEL CORPORATION

Alloy Steel Division • Massillon, Ohio

GENERAL OFFICES • CLEVELAND 1, OHIO

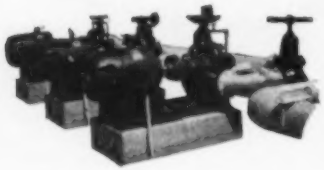
Export Department: Chrysler Building, New York 17, N. Y.

Enduro **STAINLESS STEEL**

REG. U. S. PAT. OFF.

REPUBLIC STEEL

✓ **Check ALL 10 Advantages:** • RUST AND CORROSION-RESISTANCE • HEAT-RESISTANCE • HIGH STRENGTH • NO METALLIC CONTAMINATION • SANITARY SURFACES • EASY TO CLEAN • EYE APPEAL • EASY TO FABRICATE • LONG LIFE • LOW COST.



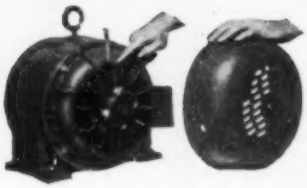
How do

ON MOTORS

Q. As applied to a motor, what does "explosion-proof" actually mean?

1) *That the motor's operation is not affected by external nearby explosions?*
2) *That gastight construction prevents entry of gas or vapors that might explode inside the motor?*
3) *That the motor's enclosure withstands internal explosion and keeps sparks from escaping outside?*

A. An explosion-proof motor (Class I Group D) has an enclosure which will withstand an explosion of a specified gas or vapor which may occur within it, and prevent resulting sparks, flashes, or explosions from igniting the specified gas or vapor surrounding the motor. G-E makes the most complete line of motors tested and listed by UL for hazardous locations in refinery service—in some cases, the only ones so listed. See Bulletin GEA-4131.



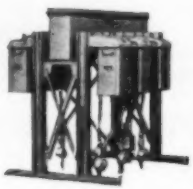
Q. What's the newest development in corrosion resistance for refinery motors?

1) *A newly developed paint immune to acids and alkalies?*
2) *A new type of cooling fan?*
3) *A special grease lubricant for ball-bearings?*

A. It's G-E's new Textolite® corrosion-resistant cooling fan, now supplied in all Tri-Clad® totally enclosed fan-cooled motors in ratings from 1 to 15 hp. Added to Tri-Clad's corrosion-resistant cast-iron enclosure, the new fan now makes these standard, off-the-shelf motors available for refinery service regardless of the acids and alkalies that may be encountered. It's nonsparking, too, and tested and listed by UL for use in explosion-proof motors for hazardous areas Class I Group D, and Class II Groups E, F, and G. Send for Bulletin GEA-4400 on Tri-Clad totally enclosed motors.

Q. If you were placing low-voltage control in a hazardous or semi-hazardous location, what equipment would you specify?

1) *Separate units and wall-mount?*
2) *Circuit breakers separate from starters?*
3) *A factory-assembled group unit?*



A. The convenient, time-saving way is to specify a racked-up assembly of G-E combination starters and breakers designed especially for indoor or outdoor refinery use. It's a standard, factory-built arrangement, with all control units mounted on a self-supporting framework. Available are corrosion-resisting, oil-immersed, and air-break explosion-proof types, the last two for Class I, Group D locations. Bulletin GEA-3541 gives data on oil-immersed starters.

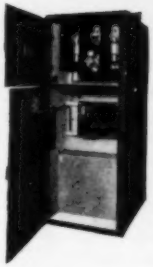
GENERAL ELECTRIC

you rate ?

AND CONTROL

Q. When you want to combine high-voltage motor control with short-circuit protection in a semi-hazardous area, what do you do?

1) *Order circuit breakers magnetic starters, and overload relays separately?*
2) *Specify group-assembled controllers as one unit?*
3) *Install magnetic starters and provide for short-circuit protection by means of separate safety switches?*



A. You would do best by specifying high-interrupting capacity G-E refinery-type Limitamp controllers, with sealed current limiting fuses which serve both as fuses and disconnect switches. Contactors are oil immersed or in explosion-proof cases. These compact units are completely wired ready to be quickly and inexpensively installed. They are furnished as single units or as a complete group of several units, including incoming oil-circuit breakers and transformer feeders. Check Bulletins GEA-4247 and GEA-3660.

Q. For what reason would you specify a motor control center?

1) *It saves space?*
2) *It simplifies future expansion?*
3) *Easy installation and maintenance?*

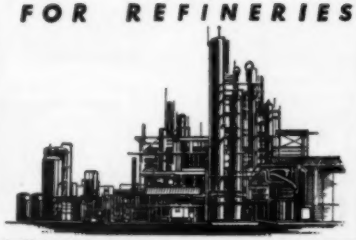
A. All three features characterize the new G-E motor control center, with which you can plan the right combination for your plant's needs. Compact, self-enclosed starting units (in four size ranges, from NEMA size 1 to 4, inclusive) fit interchangeably within vertical sections. Front-connected wiring simplifies installation, changes and maintenance. Sections can be placed back to back or against a wall to utilize available plant space. Bulletin GEA-4979 describes the new G-E motor control center.

G.E. MAKES DOUBLY SURE YOU GET THE RIGHT ELECTRIC EQUIPMENT

Bring your questions on the selection of motors and control to General Electric. For G.E., over the years, has developed the most complete line of electric equipment to meet specialized refinery needs. What's more—to make doubly sure your selection is correct—G.E. teams up two or more engineers to advise you. Specialists who know their particular lines of electric equipment inside out work hand in hand with an "industry" man who is thoroughly at home with refinery practice and electrical needs. With their pooled knowledge and experience to draw on, you're certain to meet your requirements practically, economically. Check your nearest G-E office and help yourself to this "extra." For more information on motors and control, send in the coupon.

MOTORS AND CONTROL

FOR REFINERIES



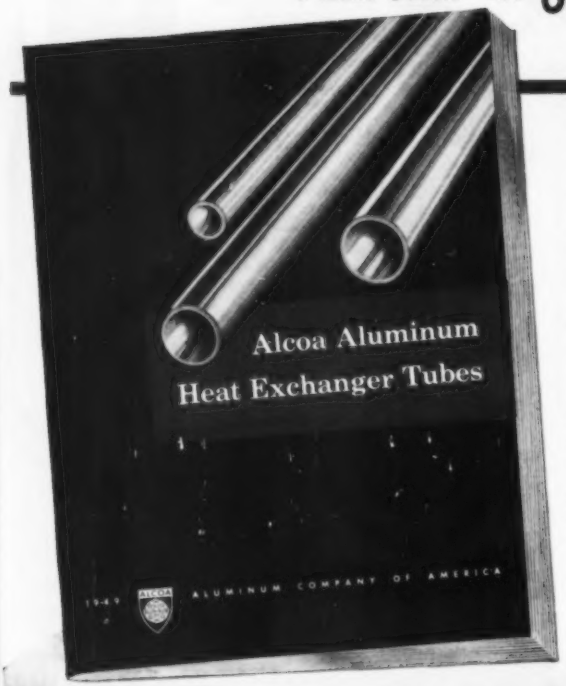
General Electric Company, Section D654-87
Apparatus Department, Schenectady 5, N. Y.

Please send me the following information on G-E motors and control for refineries.

.....*GEA-4131—Motors and control for hazardous locations*
.....*GEA-3541—Oil-immersed starters*
.....*GEA-4400—Tri-Clad totally enclosed fan-cooled motors*
.....*GEA-3660—Limitamp controllers with oil-immersed contactors*
.....*GEA-4247—Limitamp controllers with air-break contactors*
.....*GEA-4979—Motor control center*

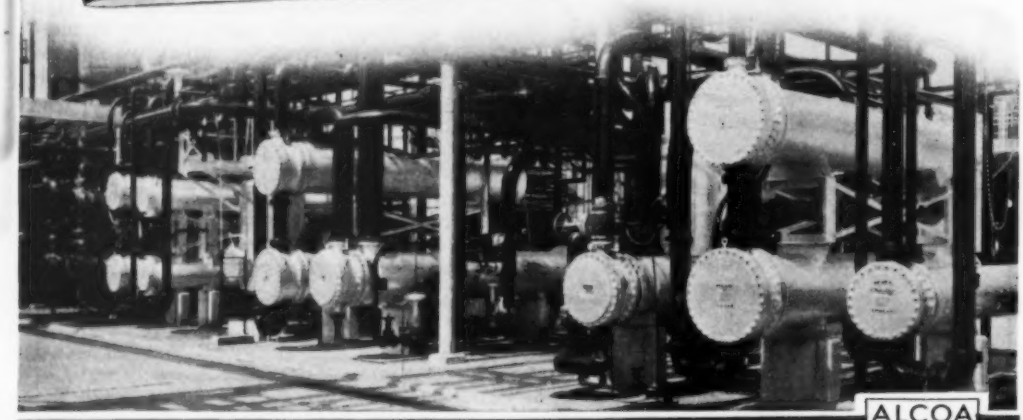
Name.....
Company.....
Address.....
City.....State.....

LOW COST ALCOA HEAT EXCHANGER TUBES PERFORM IN Sub Zero Temperatures



Liquefied gases take the fight out of most metals. This book tells how they toughen and strengthen Alcoa Aluminum Heat Exchanger Tubes. Aluminum tubes frequently last more than 15 years in refinery service. These properties make them your logical choice for tonnage oxygen, gas liquefaction, propane extraction, dewaxing and any other processes involving low temperatures.

Alcoa Exchanger Tubes pack all these advantages at a cost approximately ½ of Admiralty, ⅔ of cold drawn seamless steel, ⅙ of stainless or monel. The complete story is in the booklet, "Alcoa Aluminum Heat Exchanger Tubes". Ask your nearby Alcoa sales office for a free copy. Or write ALUMINUM COMPANY OF AMERICA, 696 Gulf Building, Pittsburgh 19, Pennsylvania.



ALCOA ALUMINUM
HEAT EXCHANGER TUBES

ALCOA

Built to Keep Instrument Up-Keep DOWN

1. *Vacuum Tubes* reduce maintenance
2. *Mercury Switches* reduce maintenance
3. *Enclosed Motor* reduces maintenance
4. *Enclosed Slide Wire* reduces maintenance

YES, *ElectroniK* POTENTIOMETERS ARE RUGGED!

Yet with all this, ElectroniK Potentiometers possess greater accuracy, sensitivity and speed of response. Try them and you'll see . . . they have been acclaimed for outstanding performance for eight years in all industries.

MINNEAPOLIS-HONEYWELL REGULATOR CO.
BROWN INSTRUMENTS DIVISION
4498 Wayne Ave., Philadelphia 44, Pa.
Offices in principal cities of the United States, Canada and throughout the world

ElectroniK Potentiometers . . . strip chart, circular scale and circular chart . . . are fully explained and described in Catalog 15-13. A copy will be sent to you upon request . . . write today!

BROWN *Advanced Instrumentation* FOR THE PETROLEUM INDUSTRY
Product of MINNEAPOLIS **Honeywell**

REAPPRAISING FUEL VOLATILITY

Changes in fuels and engines are increasing the importance of volatility as a factor in engine performance

IT IS THE GOAL of oil refiners to be able to manufacture high quality gasoline at minimum cost. This objective can be furthered if full use is made of blending-stocks of a wide range of volatility.

The increase in octane number of motor fuels which occurred during the years just prior to World War II was accompanied by an increase in volatility. This occurred because the processes generally available permitted the production of base gasolines of higher antiknock value only by lowering the end points. (Chart opposite: broken lines.)

Today, however, while there are some refiners who have an excess of high-volatility stocks of good antiknock quality, there are others who, because of the use of new refining processes, may find it advantageous to produce quantities of high-antiknock stocks of relatively low volatility. (Chart opposite: solid lines.)

The ability of such refiners to blend these stocks into motor gasoline may often result in greater flexibility and economy of refinery operation. The feasibility of thus adding to stocks available for gasoline blending, however, is dependent not only upon the relative demand for the different types of refinery products, but also upon the compatibility of the finished gasolines with currently used engines.

The needs of automotive transportation—as well as national security—in an increasingly complex economy, are served best by the greatest possible flexibility in the refining of petroleum products. It is desirable, therefore, that automotive designers make every effort to minimize the sensitivity of engines to fuel volatility.

The problem of using gasolines that contain high-boiling fractions, in particular, presents a challenge to the automotive engineer, because it is not desirable that their distribution to the cylinders be obtained through excessive heating of the intake manifold. Such heating not only reduces volumetric efficiency and power output, but tends to depreciate the antiknock quality of highly sensitive cracked fuels.

Problems of vapor-lock

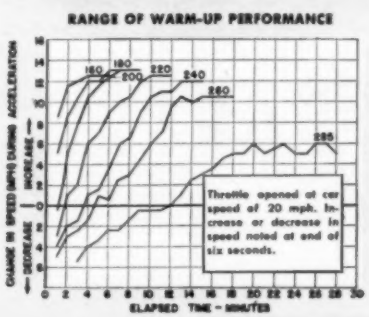
The use of gasolines containing the lighter hydrocarbons also presents problems of engine design. High-volatility gasolines, under some conditions of service, may result in vapor-lock of fuel systems, but experience indicates that much can often be done in the design of both engine and chassis to permit the use of more volatile fuels. When vehicles can utilize the lighter fuels without the occurrence of vapor-lock, the definite advantages of easier starting and quicker warm-up are made available to users of automotive vehicles.

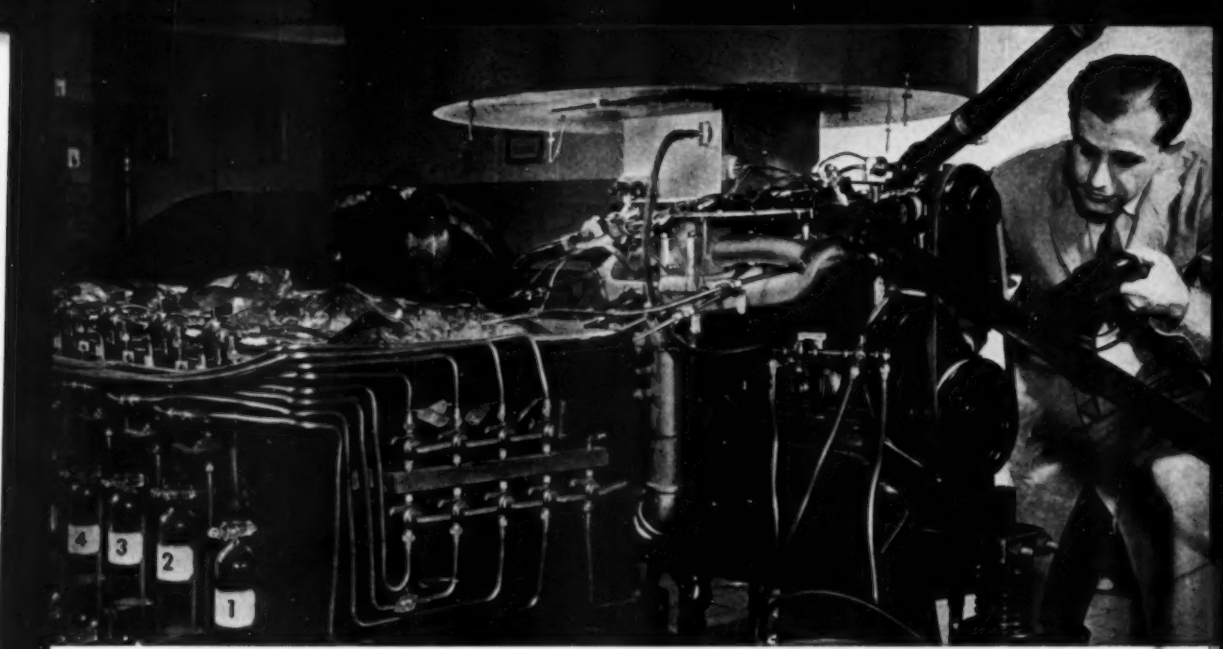
Volatility of gasolines is an important factor in connection with the formulation and utilization of "Ethyl" brand of antiknock compound. As a consequence it has played and will continue to play an important part in the program of the Ethyl Research Laboratories. And like so many fuel problems, those associated with gasoline volatility inseparably involve the manufacturers of engines, base fuels, and antiknock compounds.

The Ethyl Laboratories have participated extensively in cooperative programs with oil companies and auto-

Research on the warm-up characteristics of cars is conducted in this "cold room" of the Ethyl Research Laboratories. Here a car can be operated under highway conditions, and at controlled temperatures as low as −10°F.

Large variations in the warm-up performance of a car may result from the use of gasoline of different volatilities. These curves were plotted from data obtained during a cooperative program with Gulf Research & Development Company.


RANGE OF WARM-UP PERFORMANCE
CHANGE IN SPEED (MPH) DURING ACCELERATION
— DECREASE — INCREASE —
160
180
200
220
240
260
285
Throttle opened at car speed of 20 mph. Increase or decrease in speed noted at end of six seconds.
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
ELAPSED TIME — MINUTES



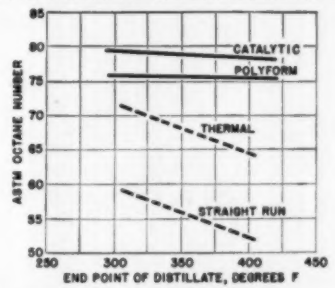
Much of the equipment in the Ethyl Research Laboratories is designed particularly for use in engine-fuel problems. This special equipment is used for studying the relationship between base fuel volatility and the distribution of "Ethyl" antiknock compound to the cylinders of an engine.

motive manufacturers in studies relating to vapor-lock, in work intended to determine the effect of fuel volatility on engine performance, and in projects intended to enable designers to adapt their engines most satisfactorily to the volatility of fuels supplied by the oil industry.

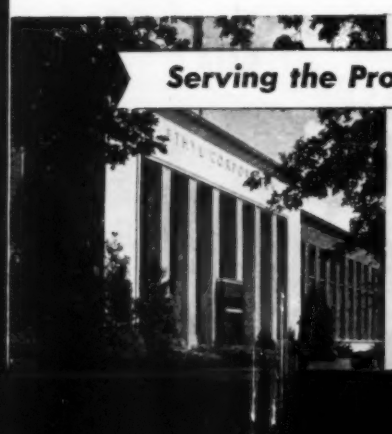
Research related to gasoline volatility is only one of the many services provided by the Ethyl Laboratories for oil companies. A comprehensive and continuous research program provides information which assists refiners directly in the economical production of satisfactory gasoline and furnishes basic data which serve as a foundation for development programs related to gasolines, engines, and crankcase oils.

This message is the twelfth in a series dealing with problems faced by refiners in producing gasoline for today's and tomorrow's engines, and the contribution of the Ethyl Corporation to their solution. Future messages will discuss other phases of this complex problem.

OCTANE NUMBER OF GASOLINE COMPONENTS



Blending-stocks whose heavy ends have high antiknock quality may be produced by new refining methods such as catalytic cracking and polyforming.



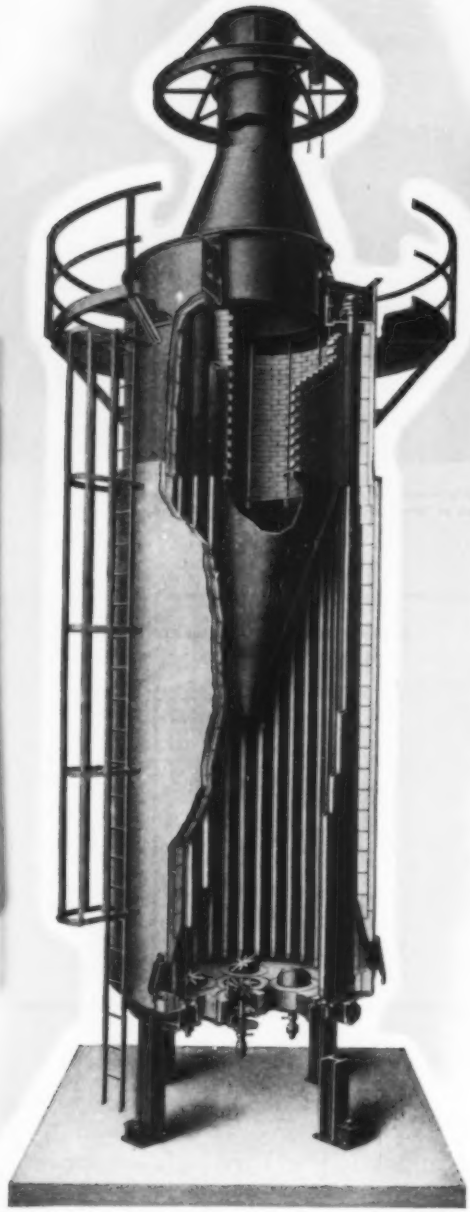
Serving the Progressive Petroleum Industry Through Research

ETHYL CORPORATION

RESEARCH LABORATORIES

DETROIT, MICHIGAN . . . 1600 WEST EIGHT MILE ROAD

SAN BERNARDINO, CALIFORNIA . . . 2600 CAJON ROAD



OK! say designers in the process industries

THE ISO-FLOW FURNACE HAS BEEN ACCEPTED FOR THE MOST SENSITIVE SERVICES . . . AND THE MOST RUGGED

A few years ago somebody had an idea. It was *only* an idea, then. Today, in Petro-Chem's Iso-Flow Furnace, this idea is considered so practical that the process industries have widely approved it.

FOR SENSITIVE SERVICES? SURE—

Propane deasphaltizing . . . methyl-ethyl-ketone dewaxing . . . furfural extract and raffinate heating . . . catalytic treating . . . catalytic reforming . . . vacuum flashing of catalytic feed stock, etc.

WHAT ELSE?

The most rugged services you can think of . . . such as gas cracking at 1500° F.

Why this emphatic OK? Primarily because of *even-heat distribution,* combined with the efficiency required by plant location and plant economics.

For full details, call Bethlehem Supply. Bethlehem's refinery staff will be glad to render trained engineering assistance, from specifications to operation.

BETHLEHEM STEEL

BETHLEHEM SUPPLY COMPANY

General Offices: 21 E. Second St., Tulsa, Okla.

Subsidiary of Bethlehem Steel Corporation

GHQ FOR REFINERY SUPPLIES

CREATING *nothing* TO ASSURE LONG LASTING SERVICE

QUAKER HOSE IS VACUUM "PRE-TESTED" FOR STRENGTH OF WALLS . . . DURABILITY IN HANDLING PETROLEUM

If it has the Quaker trade-mark it must be right . . . each type of hose must meet rigid "pre-tests" before it is shipped for service in the petroleum industry. Scientific pre-tests that subject hose to torture-tests more severe than will ever be encountered in production, refining or transportation.

One of these steps in "pre-testing" Quaker Hose is shown above. A vacuum test that puts Quaker Hose through the paces to provide rubber products for the petroleum field that are second to none in quality.

This is only one of the eighteen rigid tests that raw materials and finished products must pass before receiving the Quaker stamp of approval. Yes, "pre-testing" of Quaker belting, hose and packings provides quality and long service so necessary in the petroleum industry in maintaining maximum production with the minimum amount of maintenance.

PACKINGS THAT PRESERVE POWER

Quaker pump packings are pre-tested for size, shape and quality to assure perfect fit, long service, maximum power.

BELTS THAT BOOST POWER

Quaker's complete line of transmission belting for every installation in the petroleum industry is pre-tested and service-proved to provide sure-grip . . . slip less . . . save power.

QUAKER RUBBER CORPORATION

PHILADELPHIA 24, PA. • New York 7 • Cleveland 15 • Chicago 16 • Houston 1

Western Territory

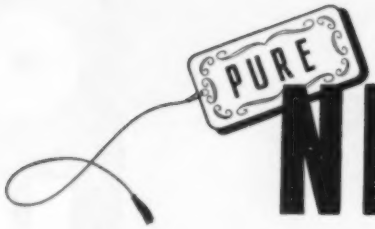
QUAKER PACIFIC RUBBER CO. • San Francisco 10 • Los Angeles 21 • Seattle 4

QUAKER

RUBBER PRODUCTS

QUAKER RUBBER CORPORATION QUALITY SINCE 1885

REG. U. S. PAT. OFF.



NICKEL

Sheet, Strip, Rod, Wire, Tubing, Clad-steel, Castings.

Its practical cost astonishes users almost as much as its distinctive characteristics

CHEMICAL COMPOSITION

The nominal composition of commercially pure wrought Nickel is:

Nickel*	99.4%
Copper	0.1
Iron	0.15
Manganese	0.2
Silicon	0.05
Carbon	0.1

**Including cobalt*

PHYSICAL CONSTANTS

Specific Gravity	8.89
Density, lb. per cu. in.	0.321
Melting Point	2615-2635°F. / 1435-1445°C.
Specific Heat at (80-212°F.)	0.130
Heat Expansion Coefficient at (80-212°F.), per °F.	0.0000072
Thermal Conductivity at (80-212°F.), Btu/sq. ft./hr./°F./in.	420
Electrical Resistivity at 32°F., ohms/cir. mil. ft.	63
Temperature Coefficient of Electrical Resistivity per °F.	0.0022-0.0028
Modulus of Elasticity in tension, psi	30,000,000
in torsion, psi	11,000,000
Poisson's Ratio	0.31

MECHANICAL PROPERTIES

The following figures for Standard Cold Rolled Sheet are typical, though the figures will vary for different forms and tempers.

Tensile Strength	55,000-80,000 psi
Yield Strength (2% offset)	15,000-45,000 psi
Elongation in 2 in.	50-35%
Rockwell B Hardness	40-70

AVAILABLE FORMS

Wire	Bar	Plate	Pipe
Rod	Angles	Sheet	Strip

Seamless and Welded Tubing
Sand and Precision Castings
Clad-Steel Plate and Strip Welding Rods

It is a strange and interesting metal, Pure Nickel. A kin of both the base metals and the precious metals. Among all the elements, no other metal possesses its unique combination of so many different and uncommon properties.

- It is highly resistant to corrosives that destroy many other metals—alkalies, many acids, salts, organic compounds, fumes.
- It has mechanical properties like those of structural steel.
- Yet it is so ductile that it can be worked into the most intricate and delicate shapes that are practical in metal.
- It protects the purity of sensitive foods, beverages and pharmaceuticals against contamination.
- It often provides a faster rate of heat transfer than metals with equal heat conductivity.
- Its special electronic properties make it a standard metal for electronic uses.
- It offers rare electrical and magnetostrictive characteristics that often give theoretical ideas a birth of practical value.
- It can be exposed to temperatures ranging into yellow heat and even hotter in the absence of sulphur.
- At sub-zero temperatures its strength increases without change in ductility and toughness.
- It is a standard metal for the cladding of steel, and as a base for gold, palladium and silver-clad products.

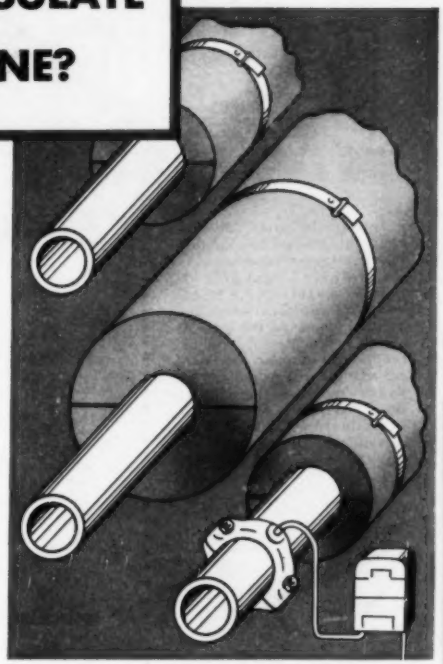
And one of the most valuable of all its features is the fact that Pure Nickel is a practical metal at a practical price.

Does it stimulate an idea of how you may find an easy answer to a difficult problem?

Our technical bulletin "Engineering Properties of Nickel" gives the important facts you want. It's yours for the asking.

The International Nickel Company, Inc.
67 Wall Street, New York 5, N.Y.

HOW WOULD YOU INSULATE THIS HOT LIQUID LINE?



A 3" line running 100' through a 75° F. room carries a hot, viscous fluid at 225° F., flowing continuously at the rate of 40' per minute. Temperature of the fluid at the delivery end must not drop more than 5° F. How would you hold the proper temperature in the line?

- ☐ Standard thick 85% Magnesia
- ☐ 3-inch thick 85% Magnesia
- ☐ External heat source and Standard Thick Magnesia

Here's what the Armstrong engineer recommended:

In industries where control of process temperatures is vital to successful operation, insulation can be designed to help hold those temperatures accurately. Writing the specification that best meets the requirements of the job calls for careful study of all factors involved, as well as a thorough knowledge of just what insulation can do and its limitations.

In the problem outlined above, with the liquid flowing through the pipe continuously, the Armstrong engineer calculated that 3" of 85% Magnesia would hold the temperature to within the allowable 5° of 225° F., at the delivery end of the 100' run of pipe.

However, on jobs where pipe runs are long and flow is intermittent, no practical amount of insulation will prevent a viscous liquid from cooling and solidifying in the line. Under these conditions, an external heat source, such as charging the line with a low voltage or running a steam tracer, should be used. These methods also need insulation to operate efficiently.

Whether you need insulation to make a process work, or to cut heating or power costs, Armstrong engineers are well qualified to help you arrive at the right specification for the particular job. And the complete contract service for heat insulation offered by Armstrong also includes a full line of top quality materials and skilled workmen to apply them.

FREE INSULATION CHART

This chart lists types and thicknesses of insulation for temperatures from 300° below zero to 2800° F. Write today to Armstrong Cork Company, Industrial Insulation Department, 7503 Maple Ave., Lancaster, Pennsylvania.

ARMSTRONG'S INDUSTRIAL INSULATION

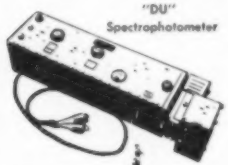
Complete Contract Service For All Temperatures

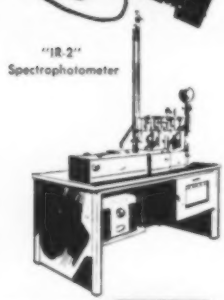
From 300° Below Zero

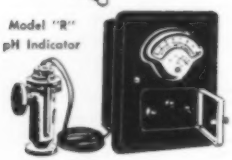
To 2800° Fahrenheit

Mark of a *modern* refinery...

In both industry and science the name "Beckman" has become synonymous with leadership in a vital field of instrumentation—that of adapting complex scientific advancements to the quick, simple, accurate solution of modern production, analytical and control problems. If you are not using these Beckman Instruments in *your* operations, we suggest you investigate today the vital savings they can make for you...


"DU" Spectrophotometer


"IR-2" Spectrophotometer


Model "R" pH Indicator

OTHER BECKMAN INSTRUMENTS include the Photopen Recorder, the Ultrohmeter, numerous types of Radiation Meters, and other advanced equipment for specialized applications. For modern instrumentation needs bring your problem to Beckman.

BECKMAN "DU" QUARTZ SPECTROPHOTOMETER:

Widely used by leading refineries to simplify the measurement and control of aromatics, butadiene and other refinery products that are readily analyzed by visible and ultraviolet light. With this instrument, complex analyses requiring many hours by other methods can be made—accurately—in a few minutes. Butadiene analyses can be made to an accuracy within 1/10 of 1% of total original sample.

Makes toluene determinations in minutes instead of hours—accurate to within 1% of toluene present over concentration range 0.01 to 100%. Also simplifies many other refinery applications with similar speed and accuracy.

Covers wide spectral range—near infrared, visible and ultraviolet—and entire instrument is designed for maximum accuracy, operating simplicity and compactness. Unusually rugged construction minimizes maintenance and insures sustained accuracy. Incorporates many unique design features. *Write for full details.*

BECKMAN "IR-2" INFRARED SPECTROPHOTOMETER:

Originally developed to simplify control problems in refinery operations, Beckman Infrared equipment and methods have been widely adopted by other industries as well.

The "IR-2" Spectrophotometer is the most advanced infrared equipment available and embodies far-reaching developments that greatly increase the versatility, accuracy, speed and convenience of modern infrared methods.

Analyzes hydrocarbons and other organic gases, liquids and solids by measuring absorption of infrared radiation at selected wave lengths, permitting rapid identification of each component—and its concentration—in complex mixtures. It is many times faster than other methods... is accurate to within ½ of 1% of *total* sample present... is simple to use and readily analyzes even the most complex mixtures encountered in modern refinery operations.

This instrument is widely used in leading refineries throughout the world, and no refinery, large or small, can be completely modern in its operating efficiency without Beckman "IR-2" equipment. *Write for full details on the many outstanding design and performance features incorporated into this equipment.*

BECKMAN GLASS ELECTRODE pH EQUIPMENT:

Extensively used throughout the refining industry to control pH in various processing operations, and to reduce costly corrosion of plant equipment by neutralizing acid crudes and similar corrosive elements.

Beckman—pioneer of modern glass electrode pH equipment—offers the widest range of pH instruments and the industry's most complete range of glass electrodes for use with its instruments.

There is a Beckman pH instrument for every application—laboratory, plant and field, as well as *completely automatic* equipment for large-scale pH indication, recording and control. Illustrated at left is the Beckman Model R Indicator for automatic pH installations, one in a complete range of pH instruments. *Write for descriptive details on Beckman pH equipment.*

Our trained research staff will outline the important savings you can make by installing Beckman instruments on *your particular* operations. Write, wire or phone for further details. *Beckman Instruments, National Technical Laboratories, South Pasadena 25, Calif.*

BECKMAN **INSTRUMENTS CONTROL MODERN INDUSTRIES**

pH Meters and Electrodes — Spectrophotometers — Radiation Meters — Special Analytical Instruments

*Water Treatment?
You Bet!

THE BIRD-ARCHER 8-POINT WATER TREATMENT SERVICE

All or any part of this service is available to you

1. *Study of all available water sources*
2. *Plant survey*
3. *Laboratory Service for scientific analysis*
4. *Development of treatment and control systems*
5. *Instructing plant staff in the operation and control of the treatment system*
6. *Furnishing properly prepared treatment materials*
7. *Specifying any equipment necessary*
8. *Regular check-ups by service engineers*

Babu, the elephant's mahout, takes good care of his mobile power plant. After lugging logs and timber through the forest all day, his elephant gets a complete water treatment at the river. His feet are kept free of *scale* and *dirt*. He's rubbed and scrubbed . . . given the best of care because that's the best way to get work out of an elephant.

The best way to keep water and steam handling equipment at peak efficiency is with the aid of Bird-Archer water treatment. More than 60 years of experience lie behind Bird-Archer methods for combating scale and corrosion. The results in thousands of cases . . . lower operating costs, increased efficiency, longer equipment life.

Bird-Archer offers a complete 8-point service — all or any part of which is available to you. Put a note on your pad now to discuss your specific problems with a Bird-Archer field engineer.

BA-193

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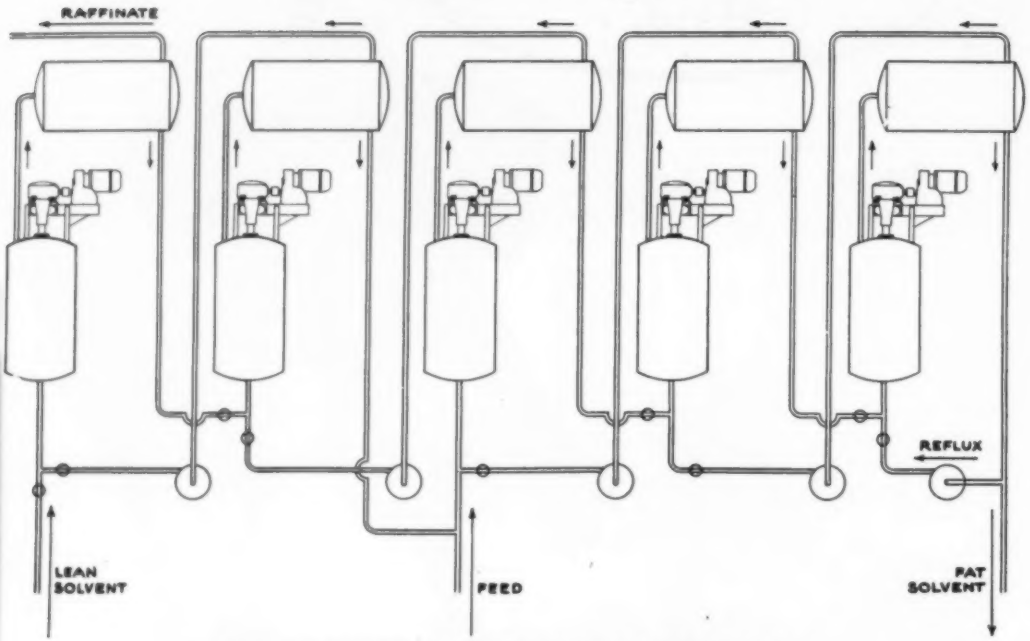
Turbo-Topics



SOLVENT EXTRACTION

Other General American Equipment

TANKS . . .
Crude • Gasoline • Propane
Butane • Chlorine • Acid
Blending • Mixing • Water

TOWERS
Absorber • Flash
Bubble • Pressure
Vacuum • Fractionating

DEWAXING FILTERS
STACKS • BINS
STEEL & ALLOY
PLATE FABRICATION
WIGGINS ROOFS
TURBO-TREATERS

Another refinery operation in which continuous Turbo-Treaters are being successfully used; the selective solvent extraction of a hydrocarbon mixture.

Turbo-Mixer engineers have many years experience in the design of continuous mixers for extraction and treating operations and recovery of the spent solvent.

We will be glad to discuss your problems with you.

GENERAL AMERICAN TRANSPORTATION CORPORATION

Turbo-Mixer Corporation Unit

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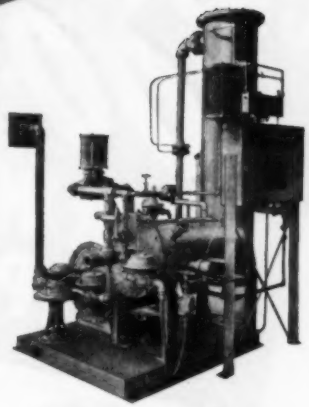
OFFICES: Chicago, Cleveland, Louisville, Orlando, Pittsburgh, St. Louis, Salt Lake City, Sharon, Washington, D. C.

INERTS in QUANTITY . . . at LOWEST COST



Model 2M1D Inert Gas Generator-2000 CFH inert gas for oil refinery use discharging at 15 inches Water Column pressure

When your industrial processing involves flammable and oxidizable vapors, liquids and dusts . . . when you need a generous quantity of pure, clean and oxygen-free inert gases . . . modern Kemp Inert-Gas generating systems provide from 1000 C.F.H. to 45,000 C.F.H. at lowest cost.

With Kemp Inert-Gas Producers you economically manufacture inert gases by completely burning gaseous fuels and appropriately processing the products of combustion . . . conveniently, right in your own plant. Large quantities of inert gases are assured through automatic, permanent, trouble-free Kemp generators, at extremely low costs: 12¢ for compressed inerts; 16¢ for low-pressure nitrogen.

You find many uses for Kemp-produced inert gases . . . to protect chemicals unloading from tank cars, protect refinery systems during down-time, reduce fire hazards, and others.

A Kemp representative will tell you the story . . . or you can send for the NEW Bulletin No. I-10 on "How To Make Your Own Inert Gases with Kemp Generators".

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PRECISION CARBURETORS • BURNERS FOR INDUSTRIAL HEAT CONTROL
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☐ Please send a Kemp representative in to see me.
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NPR-3

Another GAS PLANT 100% YARWAY EQUIPPED

COLUMBIA GAS TREATING PLANT OF ARKANSAS FUEL OIL CO. USES ALL YARWAY IMPULSE STEAM TRAPS

Again and again you hear it—Yarway Impulse Steam Traps used throughout the plant!

Here at this large southwestern plant nearly 100 Yarways are on the job on re-boilers, separators, steam turbine-driven pumps, reciprocating steam pumps and elsewhere.

Yarways are popular for these reasons:

First—they're good for *all pressures* within a wide range without change of valve or seat.

Second—Yarways speed up heating and keep equipment hotter because they discharge *continuously* on heavy condensate loads, at short intervals in lighter loads . . . keeping lines free of condensate.

Third—simple design, only one moving part, makes maintenance easy.

Fourth—it is frequently cheaper to install a new Yarway than to repair an old type trap.

See your Supply House, or write for Yarway Bulletin T-1739.

YARNALL-WARING COMPANY
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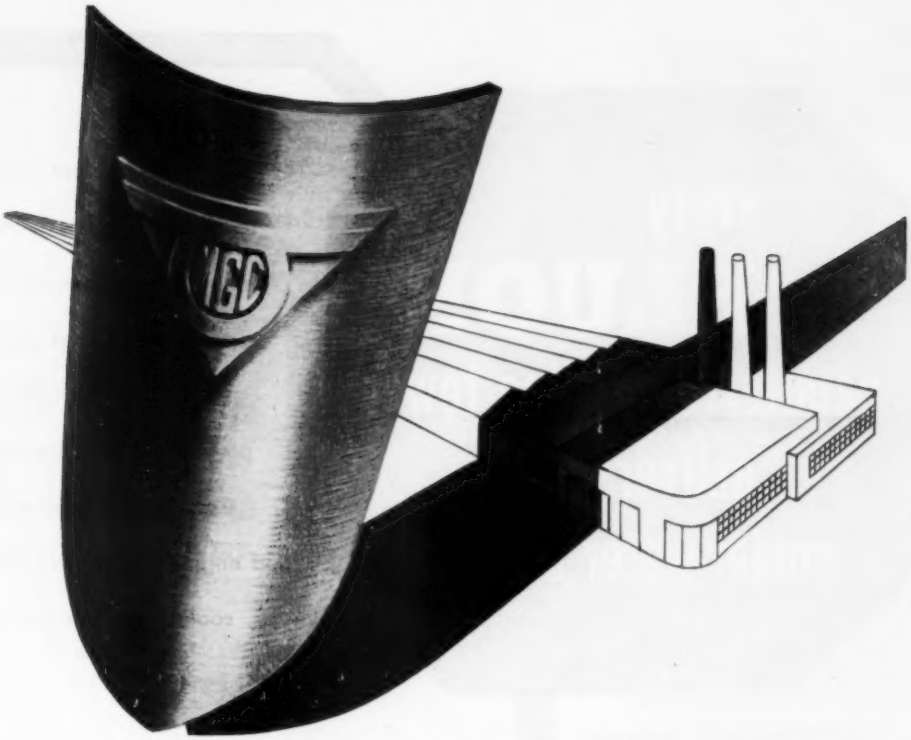
Over 600,000 Already Purchased

YARWAY IMPULSE STEAM TRAP



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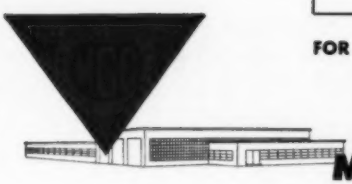
We have plenty of long-lived stainless alloys to help you armor vulnerable spots against corrosive conditions and high temperatures. Our varied stocks include stainless of practically every type, form (including Clad) and alloy you need: sheets, bars, plates, tubing or pipe . . . for immediate delivery from the largest stocks in the Southwest.

Our technicians will gladly help you select the types best suited to your specific refinery applications. For example:

Such types as 405 and 410 are especially adapted to lining reactors and fractionating columns because of their inherent resistance to sulfide corrosion at elevated temperatures.

FOR GOOD METALS . . . CALL METAL GOODS



METAL GOODS CORPORATION

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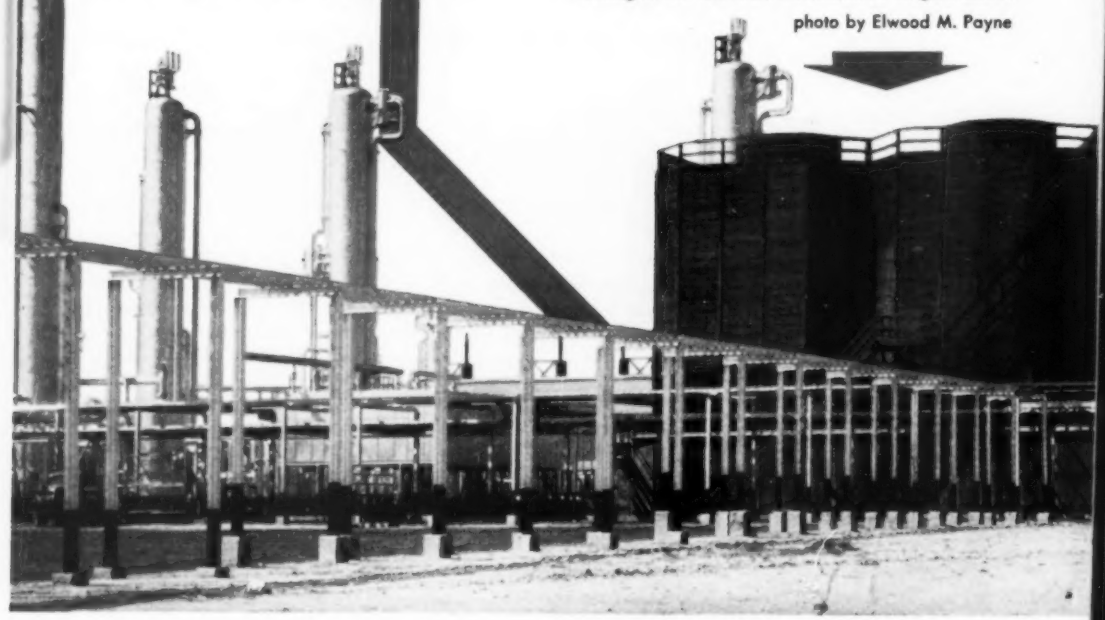
New Orleans, 432 Julia **Denver,** 817 17th St. **Kansas City,** 1300 Burlington

every **FLUOR** counterflo cooling tower delivers colder water cheaper

Every Fluor *Counterflo* tower cools to the guaranteed temperature. Does this *insured performance* cost you more? No! Fluor towers are prefabricated in standard cell sizes for low erection costs—and engineered to give maximum cooling per fan horsepower.

* **colder** Fluor towers give closest wet-bulb approach
* **cheaper** Fluor towers cost less per degree of cooling

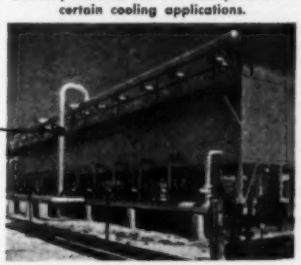


Five 30 x 30 cell coilshed cooling tower of the Counterflo induced-draft type, built by Fluor for a large gas-gasoline plant. *Guarantee:* 98° to 78° cooling at 73° wet bulb. *Performance:* as guaranteed. photo by Elwood M. Payne

aerator towers

Fluor Aerator cooling towers, have distinctive economy features and are most practical in certain cooling applications.

fin • fan units



Fluor air-cooled heat exchangers are more economical where make-up water is expensive, where water has bad scaling characteristics, and where the temperature of liquid to be cooled is relatively high. (Manufactured and sold by Fluor and Griscom-Russell Co.)

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THE FLUOR CORPORATION, LTD.

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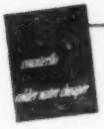


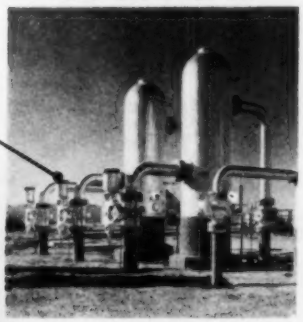
SAVE YOUR COMPANY MONEY

Before buying a cooling tower, we urge you to look at the engineering *facts* presented in the new booklet "Colder Water Cheaper". Write us for your copy.

ulsation dampeners

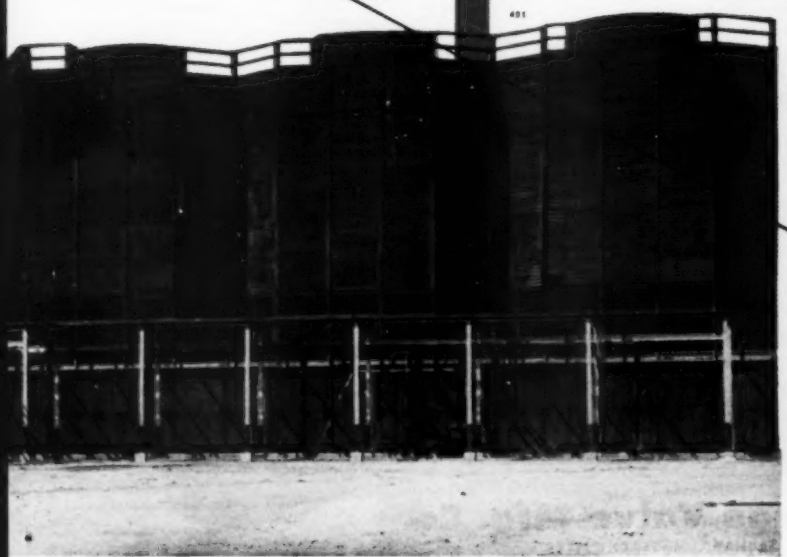
Fluor pulsation dampeners remove destructive vibrations and instrument irregularities caused by pulsative gas flow.

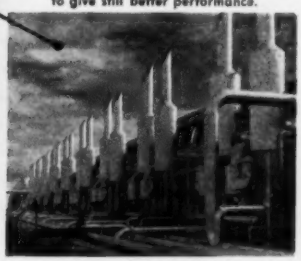
gas cleaners



The Fluor gas cleaner, already well-known for efficient cleaning, has been redesigned to give still better performance.

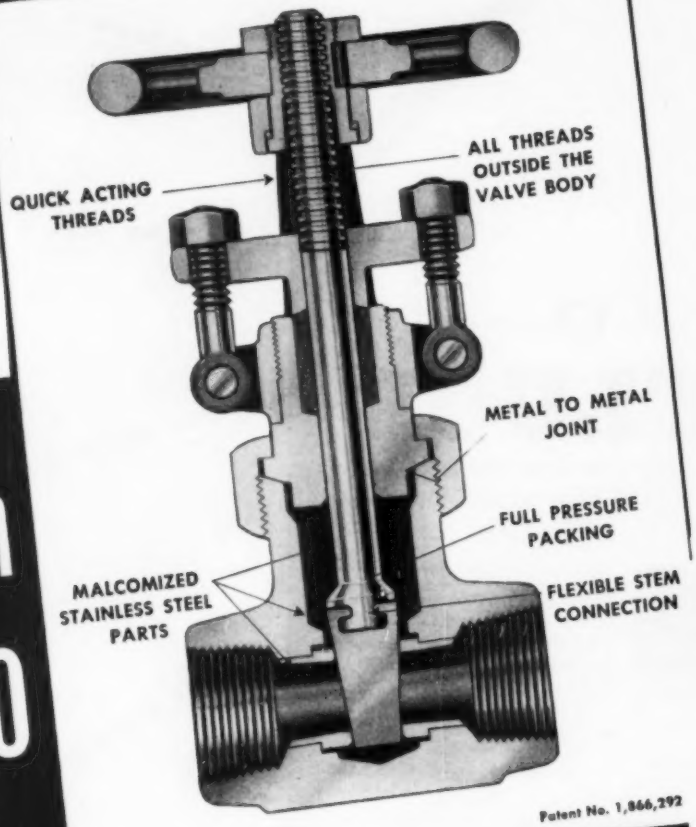
mufflers





Fluor mufflers, redesigned to incorporate pulsation-dampener principles, reduce exhaust-line noises to less than the mechanical noises of the compressor room.

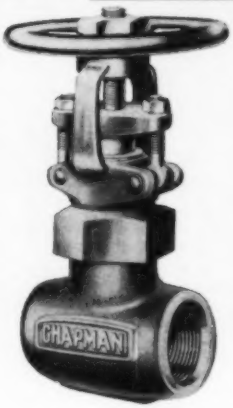
Chapman List 960



—the gate valve you can REPACK under FULL PRESSURE

This Chapman List 960 was specifically designed to simplify your maintenance problems. For instance, you can repack it without interrupting service . . . there's no pressure transmitted to the stem. And you can use it inside or out, for a forged steel packing gland protects vital yoke threads from rust and corrosion. To ensure longer wear, seats and plugs are made of superhardened stainless steel . . . body and yoke of tough forged steel.

For your best buy . . . specify the Chapman List 960. Available in sizes from $\frac{1}{4}$" to 2" . . . carbon steel for pressures to 800 pounds; alloy steel for pressures to 1000 pounds at 750°F. For higher pressures, specify List 990.



The Chapman Valve Mfg. Co.
INDIAN ORCHARD, MASSACHUSETTS

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MONO-BLOCK

. . . the one-block insulation

made with **BLACK** ROCKWOOL

effective to

Send for free copy of our catalog "Industrial Insulation" which describes B-H MONO-BLOCK and other Baldwin-Hill insulations.

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Name_____ Position_____

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55 GALLONS OF WORKING EMULSION-BREAKER

IN EVERY *Visco* BARREL!

Putting Visco dehydrating and desalting chemicals to work for you is an absolute guarantee (in writing, if you wish) of *consistently uniform* emulsion-breaking efficiency. Every one of the big blue Visco barrels contains 55 gallons of *working* emulsion-breaker... to give you minimum cost per barrel of dry oil. Call Houston, CAPITOL 7300, collect, for prompt action or more details on Visco chemicals and field service.

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Visco... CONSISTENTLY EFFICIENT DEHYDRATING AND DESALTING CHEMICALS

NOTICE: Visco Products Company is authorized to manufacture and sell Visco Oil Treating compounds for use in the breaking and resolving of oil emulsions, and to grant licenses for such use, under the following United States patents: 1,960,562; 1,960,963; 1,912,330; 1,937,259; 2,000,039; 2,050,849; 2,200,189; 2,214,782; 2,214,784; 2,226,189; 2,302,414; 2,307,815; 2,316,034; 2,318,035; 2,321,056; 2,335,514; Re. 20,715 and patents pending. Any purchaser of Visco Oil Treating compounds is authorized to use the same in the treating, breaking and resolving of oil emulsions in accordance with the above patents. The royalty for such use is included in the purchase price. Visco Products Company is authorized to and is willing to grant licenses on a royalty basis, to all companies, and to others desiring to practice the patented subject matter, under any and all of the above patents, permitting the user to purchase the oil treating compounds at will from any vendor, and to prepare the compounds for use under the above patent or patents, at a royalty charge of 20 cents per gallon. Application for license should be made to Visco Products Company, Houston, Texas.

Past masters in every step of refinery construction

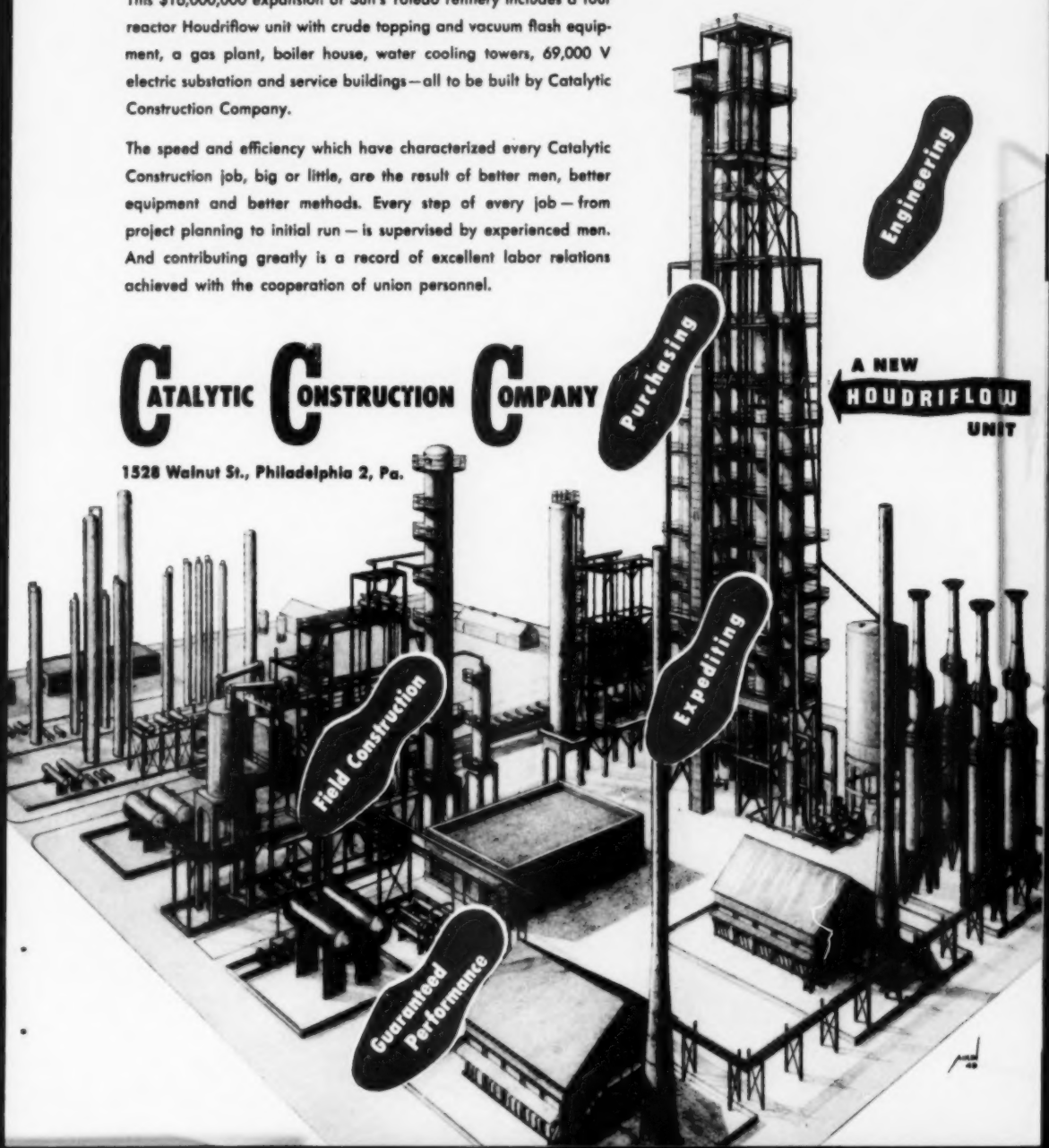
Catalytic Construction Company is a hand-picked organization of specialists in all types of refinery construction and maintenance. We can engineer and build anything . . . from a pump house to a complete refinery like the huge project pictured here.

This $16,000,000 expansion of Sun's Toledo refinery includes a four reactor Houdriflow unit with crude topping and vacuum flash equipment, a gas plant, boiler house, water cooling towers, 69,000 V electric substation and service buildings—all to be built by Catalytic Construction Company.

The speed and efficiency which have characterized every Catalytic Construction job, big or little, are the result of better men, better equipment and better methods. Every step of every job—from project planning to initial run—is supervised by experienced men. And contributing greatly is a record of excellent labor relations achieved with the cooperation of union personnel.

CATALYTIC CONSTRUCTION COMPANY

1528 Walnut St., Philadelphia 2, Pa.



For any maintenance or modernization problem... HERE'S A REAL SOLUTION!

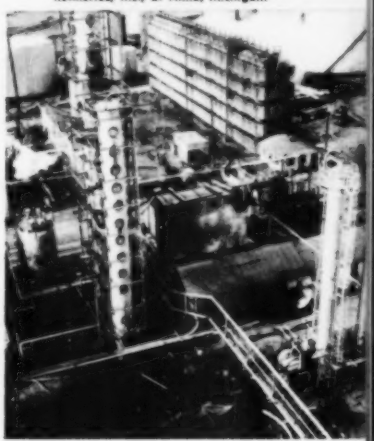
Catalytic Construction Company revamped TCC units for Ashland (above) and Continental, including modernization of kiln and reactor.

The field organization of Catalytic Construction Company includes men who have specialized for years in the design, construction and maintenance of oil refineries . . . engineers who have done all types of maintenance as well as major revamp work.

We have top-flight designers, engineers, supervisors and technicians who are familiar with every type of refinery maintenance and revamp problem from topping to Houdriflow! We can service every piece of equipment in your refinery; do a simple turnaround or a complete overhaul and modernization job.

Need help in refinery maintenance? Call Catalytic for fast service!

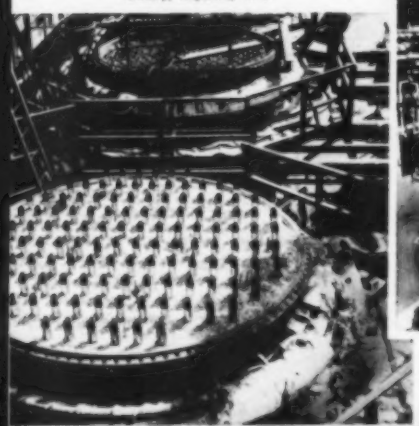
Catalytic did a general revamp of refinery equipment while building new TCC unit for Leonard Refineries, Inc., at Alma, Michigan.

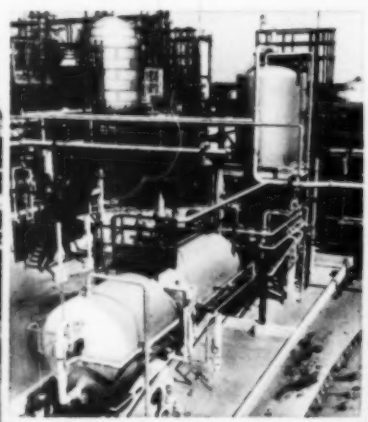


CATALYTIC CONSTRUCTION COMPANY

1528 WALNUT ST., PHILADELPHIA 2, PA.

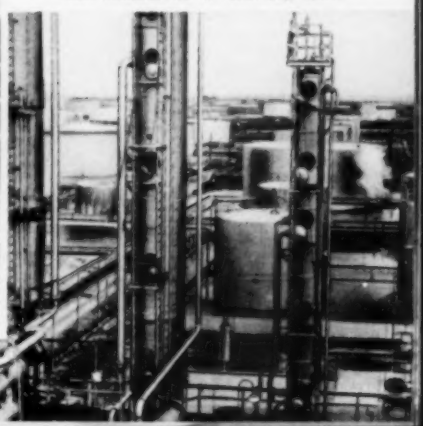
Complete modernization of Houdry fixed-bed cases at Tide Water Associated Oil refinery, Bayonne, N. J.

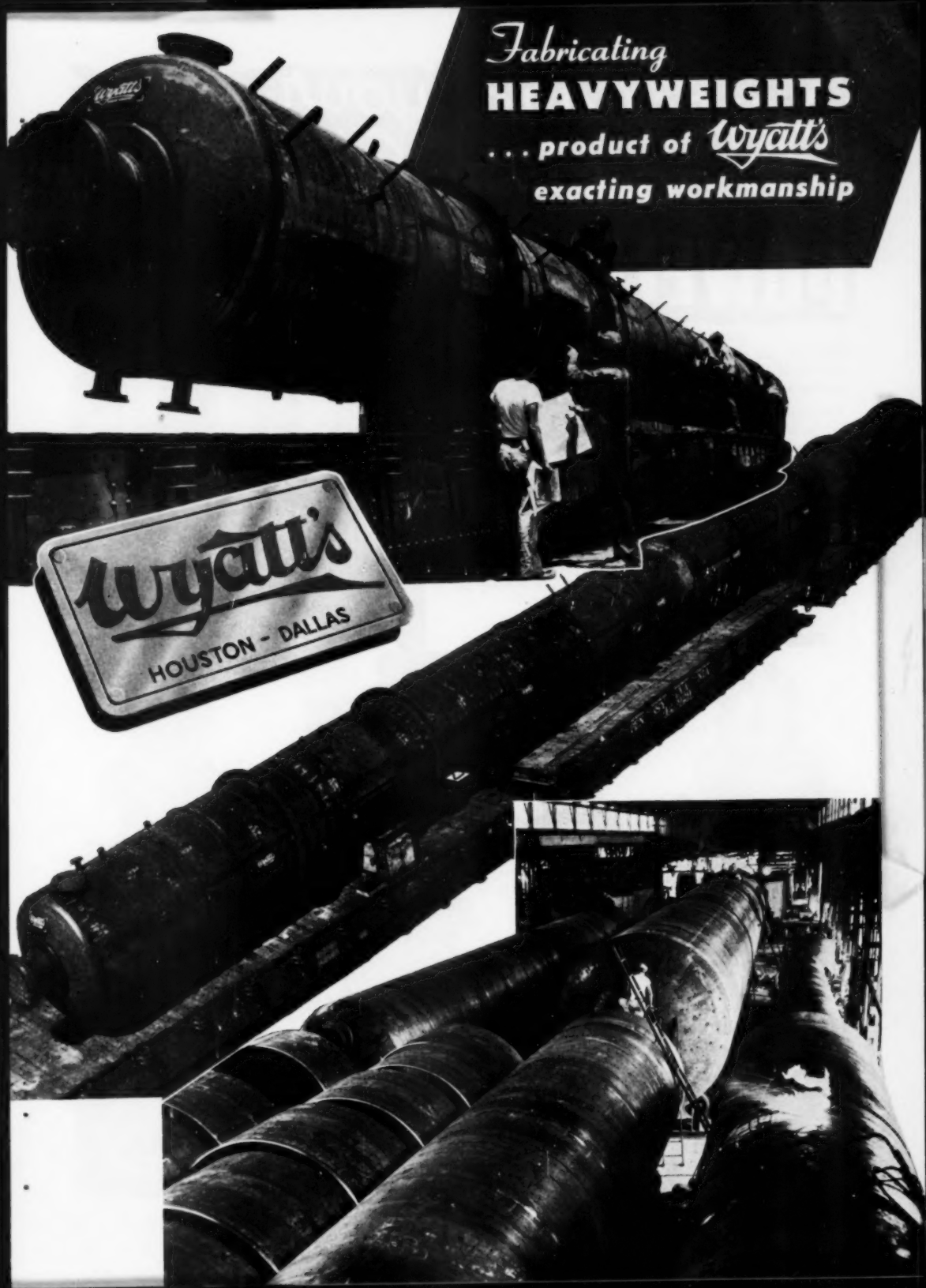




Desulphurizing unit and kerosene scrubber built by Catalytic Construction Company in Sun's Toledo refinery.

Catalytic did a complete refinery overhaul for Petrol Refineries Inc. at Texas City, Texas.

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HEAVYWEIGHTS
. . . product of Wyatt's
exacting workmanship
Wyatt's
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Safeguard your Production Goal with POWELL VALVES

Probably the chief reason why American Industry leads the world in productivity is the practice of setting up production goals—and then achieving them.

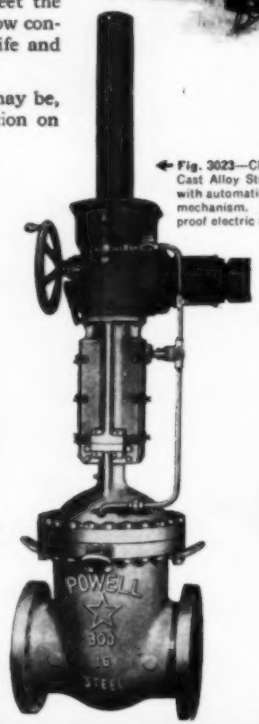
Naturally the achievement depends, to a large extent, on the human element; but in this technological age the efficiency of equipment—and especially flow control equipment—plays a major part.

That's why Powell builds a line of valves to meet the specific requirements of every known industrial flow control service. Furthermore, in every valve, long life and dependability have been emphasized.

So, no matter what your flow control problems may be, Powell has the answers. Write for full information on applications of Powell Valves.

Fig. 241—Large 125-pound Iron Body Bronze Mounted Globe Valve. Made in sizes 2" to 16", inclusive. Has outside screw rising stem, bolted flanged yoke and regrindable, renewable bronze seat and disc. Also available in All Iron.

Fig. 1375—200-pound Bronze Gate Valve with screwed ends, inside screw rising stem, union bonnet and renewable, wear-resisting "Powellium" nickel-bronze seat rings and disc.



← Fig. 3023—Class 300-pound Cast Alloy Steel Gate Valve with automatic steam sealing mechanism. Has explosion proof electric motor operator.

Fig. 1793—Large 125-pound Iron Body Bronze Mounted Gate Valve. Made in sizes 2" to 30", inclusive. Has outside screw rising stem, bolted flanged yoke and tapered solid wedge. Also available in All Iron for process lines.

The Wm. Powell Co., Cincinnati 22, Ohio

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LEAD PIPING

...keeps

Hungry Acids in Line

One of acid's most useful jobs is to serve as the "digestive juice" of the process industries. But, unless properly controlled, acids can be destructive to the "alimentary tracts" of processing systems.

• •

That's why men wise in the ways of handling acids, look to *lead* for protection. And why they look to the leader in lead . . . National Lead . . . for their lead and lead-lined pipe and fittings.

• •

National Lead offers you three types: regular all-lead pipe . . . steel pipe with cold-expanded lead linings . . . and "United Tubond" lead-lined pipe, for extreme pressure, vacuum, temperature or vibration.

• •

In "United Tubond," the lead lining is permanently *bonded* to the steel outer casing. The bore is smooth and seamless. Positive lead-to-lead joints are assured by extending the lead lining over the face of the flange.

• •

The choice depends upon the job. But whichever you choose, *look to the Leader for Lead.* You'll know you're getting all of lead's advantages, engineered by National Lead into pipe and fittings that will fight acid corrosion and mechanical stress . . . and keep hungry acids in line.

Look to the Leader for Lead

. . . in everything from lead pipe . . . valves . . . sheet . . . and lead-lined or lead-covered equipment . . . to complete acid recovery plants

NATIONAL

Lead Company

New York 6; Baltimore 3; Buffalo 3; Chicago 8; Cincinnati 3; Cleveland 13; Pittsburgh 12; St. Louis 1; Boston 6 (National Lead Company of Mass.); Los Angeles 23 (Morris P. Kirk & Son, Inc.); Philadelphia 25 (John T. Lewis & Bros. Co.); Atlanta (Georgia Lead Works, Div. of Cincinnati Branch); Toronto, Canada (Canada Metal Co. Ltd.).

For Safety,

USE ONLY GENUINE NORDCOSEAL LUBRICANTS...IT PAYS!

LUBRICANT SCREW PERFORMS TRIPLE FUNCTION

1. Lubricates seat
2. Seals around ports
3. Jacks plug

Tested types for refinery services

- Wrench, gear or cylinder operated
- ½ to 30-inch
- Pressures to 15,000 lb test

Keep Upkeep Down..

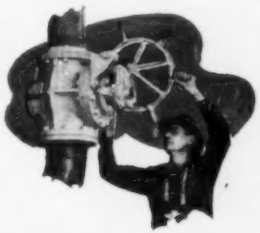
NORDSTROM VALVING INSURES SAFETY FOREVER

let lubrication guard your lines

...for easy turning, positive sealing and highest resistance to erosion and corrosion

In most refinery services line fluid cannot harm the Nordstrom seat because it is unexposed and is lubricant-protected at all times.

For infrequently operated refinery valves, lubrication is highly important. A valve dependent upon dry metal-to-metal contact can "freeze" or gall. You may have to tug and tug to break it loose; whereas lubricant keeps the Nordstrom valve in prime condition, always easy to turn.



You don't have to worry about galling or sticking. Untouched for months, a Nordstrom valve is easy to turn, easiest to tighten or adjust. There's virtually no wear-out in a Nordstrom valve if you keep it lubricated with genuine Nordcoseal lubricant. Don't use substitutes.

Make your future valve replacements with Nordstroms—it's an economy move right in line with present-day trend. The longer the valve life, the cheaper the cost. Nordstroms keep upkeep down.

Refinery valves are subjected to many severe conditions—corrosion, erosion, temperature, etc. For these tough services, lubricated valves serve best. Nordstrom valves open and close on a quarter turn. They turn easily because the rotary plug slides on a protected lubricant seat which is never exposed to the fluid in the line.

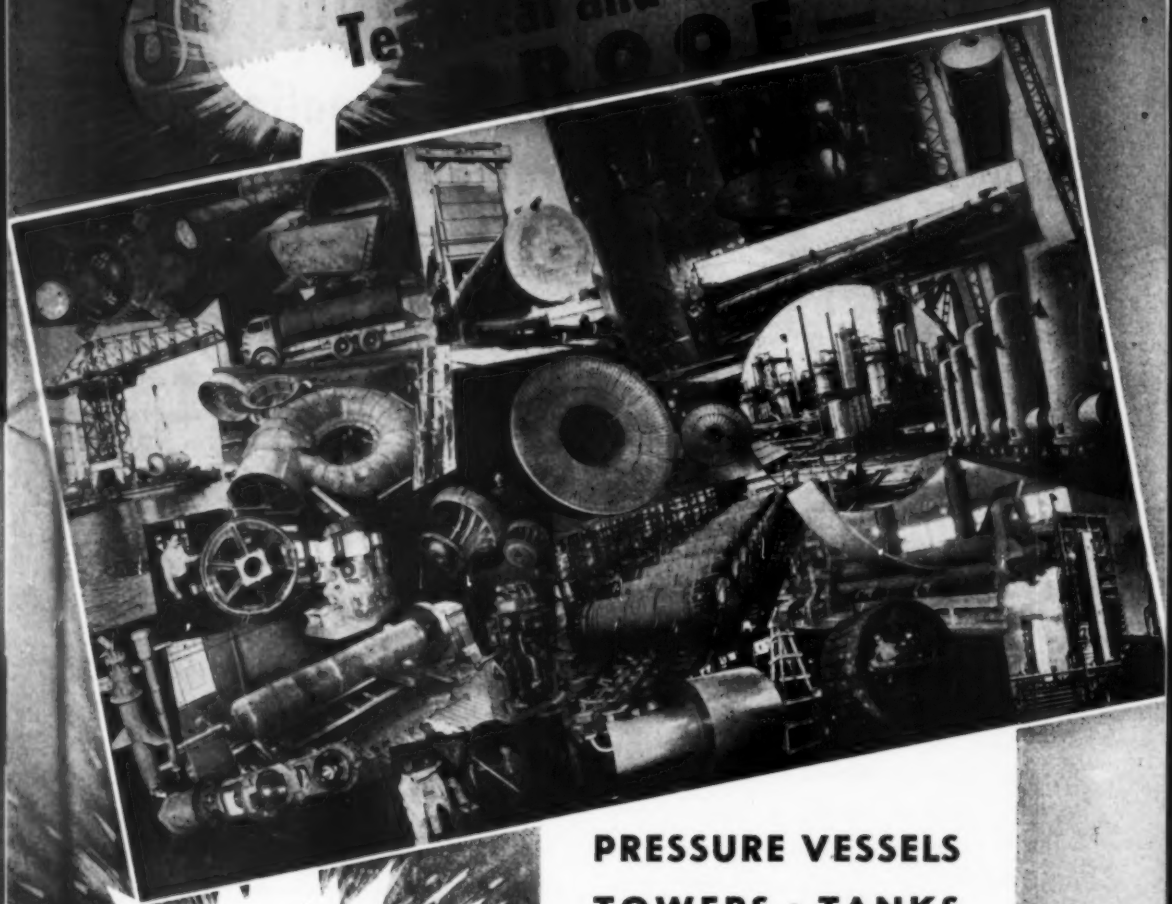
When a valve is turned frequently you want to save time and never be bothered with loosened packing. Instead of relying upon conventional packing, a resilient, anti-friction shoulder seal is used in Nordstrom valves. It has far longer life and is pressure-tight. Nordstroms hold the pressure because of accurate taper fit and because both ports are sealed with pressurized lubricant which can be increased by merely turning the lubricant screw. Nordstrom "Sealdport" lubrication is essential regardless of line pressure. Even a low pressure line needs leak-proof valves for safety.

Nordstrom

LUBRICATED VALVES

NORDSTROM VALVE DIVISION

Te cal and Engineering
ROOF



Such a
Varied Array
of Equipment gives
Assurance as to our
ability to produce your
most vital
Industrial Needs!

PRESSURE VESSELS
TOWERS • TANKS
PLATE WORK
SPECIAL EQUIPMENT
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CHESTER PA. U.S.A.

Since 1916

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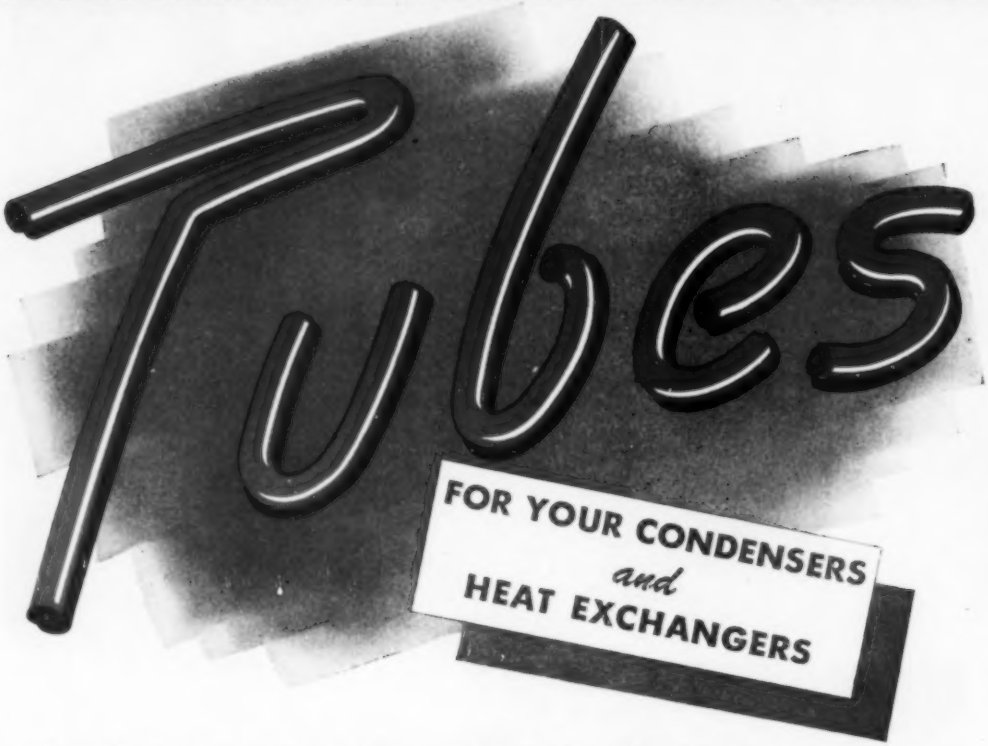
MEN OF PETROLEUM..

OFFICE WORKER... is as important to petroleum as petroleum is to our great nation. For his is the responsibility of recording operational expenses ... charting depreciation and depletion ... compiling reports ... preparing tax statements and, in general, maintaining the vast records of an industry whose benefits flow to millions of motorists—to ranchers, factory owners, storekeepers—to every American. Thanks in large part to the efforts of the office worker, more than 5,000 valuable petroleum products have been developed, enriching our lives and our industries today... promising an even greater America tomorrow.

STANDARD OIL COMPANY OF CALIFORNIA

WOLVERINE SEAMLESS NON-FERROUS



Quality controlled from ore to finished product

Available in all standard sizes from ⅜" to 2" O.D.

in **ADMIRALTY**

or These Special Alloys:

MUNTZ METAL

COPPER

ARSENICAL COPPER

"85-15" BRASS ALLOY

ALUMINUM BRASS

CUPRO-NICKEL, "30%"

CUPRO-NICKEL, "10%"

Remember, there **IS** *a difference in tubing* — **SPECIFY WOLVERINE**

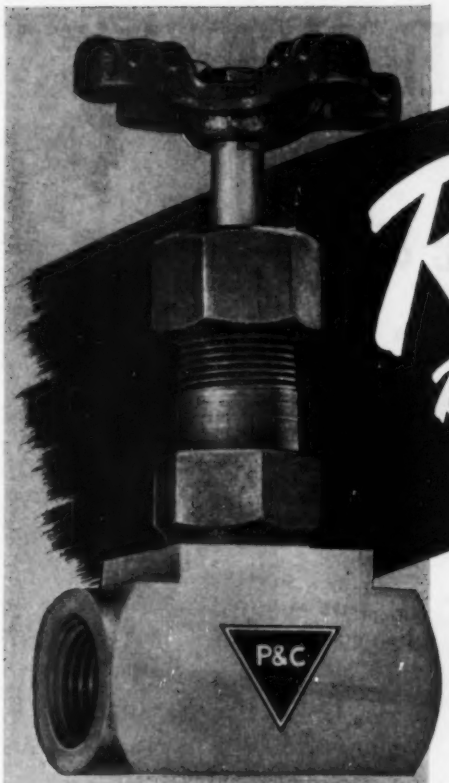
WOLVERINE TUBE DIVISION

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY
INCORPORATED

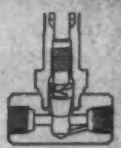
MANUFACTURERS OF SEAMLESS NON-FERROUS TUBING

1431 CENTRAL AVENUE • DETROIT 9, MICHIGAN

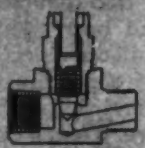
R-P & C BAR STOCK VALVES



RUGGED
ECONOMICAL
DEPENDABLE
VERSATILE

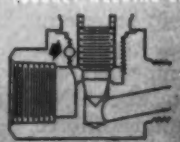


THRU-PORT—for handling heavy liquids which carry suspended solids or where precipitates or deposits cause trouble.



MALE and FEMALE END—Available in both Globe and Angle valves—useful for many special hook-ups.

—(SOCKET WELDING ENDS NOT ILLUSTRATED)—



LOCK BONNET—for lines carrying hazardous liquids or where there is extreme vibration.

UNION END—where frequent disassembly is required or to use instead of a break elsewhere in the line.

Following is a tabulation of working pressures of these valves:

MATERIAL	FIGURE NO. Globe	Angle	WORKING PRESSURE
BRONZE	1030	1031	500 lbs. at 150°F
CARBON STEEL	1040A	1041A	4000 lbs. at 150°F
			600 lbs. at 750°F
			550 lbs. at 900°F
			475 lbs. at 1000°F
12-14 CHROME STAINLESS STEEL	1050	1051	4000 lbs. at 150°F
COMBINATION	1060	1061	4000 lbs. at 150°F
12-14 CHROME STAINLESS STEEL CARBON STEEL			600 lbs. at 750°F
			550 lbs. at 900°F
			475 lbs. at 1000°F
18-8 STAIN. STEEL (TYPE 316)	1070A	1071A	4000 lbs. at 150°F
THRU PORT VALVES 1045A			1000 lbs. at 150°F
			600 lbs. at 750°F
			550 lbs. at 900°F
			475 lbs. at 1000°F

For more complete information, get in touch with your Reading-Pratt & Cady distributor or the District Office nearest you. Or, if you prefer, write direct to the factory at Reading, Pa.

ACCO

Reading, Pa. • Atlanta • Baltimore • Boston • Chicago • Denver • Detroit
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R-P & C VALVE DIVISION
AMERICAN CHAIN & CABLE

READING-PRATT & CADY VALVES

TRADE MARK

WALWORTH LUBRICATED PLUG VALVES

offer these advantages

- . . . Direct port opening
- . . . Quarter turn opens or closes valve
- . . . Dead tight shut-off
- . . . Freedom from attack by fluids being handled
- . . . Pressure sealed
- . . . Made in a complete line. Sizes from ½" to 24" for pressures from 175 to 5,000 psi., and for vacuum requirements

THESE are just a few of the reasons why Walworth Lubricated Plug Valves give "top" performance on many *difficult* services.

All Walworth Lubricated Plug Valves employ special insoluble lubricants which protect the plug and body against contact with the line fluid, thus combatting erosion and corrosion.

The lapped surfaces of the valve are "pressure sealed" when the valve is in either the open or closed position. By turning the lubricant screw, lubricant is forced under high pressure through a grooving system that completely encircles the ports as well as the top and bottom of the plug.

The lubricant seals the valve against leakage, and reduces friction between plug and body. This permits easy, quick, full-opening, or tight shut-off with only a quarter turn of the plug.

Number 1700 (illustrated) is a Steel-iron valve, wrench operated, designed for a working pressure of 200 pounds WOG (water, oil, or gas). Valves are available in either screwed or flange types. Screwed type have API line pipe thread lengths. Flanged type (No. 1700F) is faced and drilled to American Standard for 125-pound cast iron flanges unless otherwise specified.

For further information about No. 1700 as well as the complete line of Walworth Lubricated Plug Valves, write for catalog.

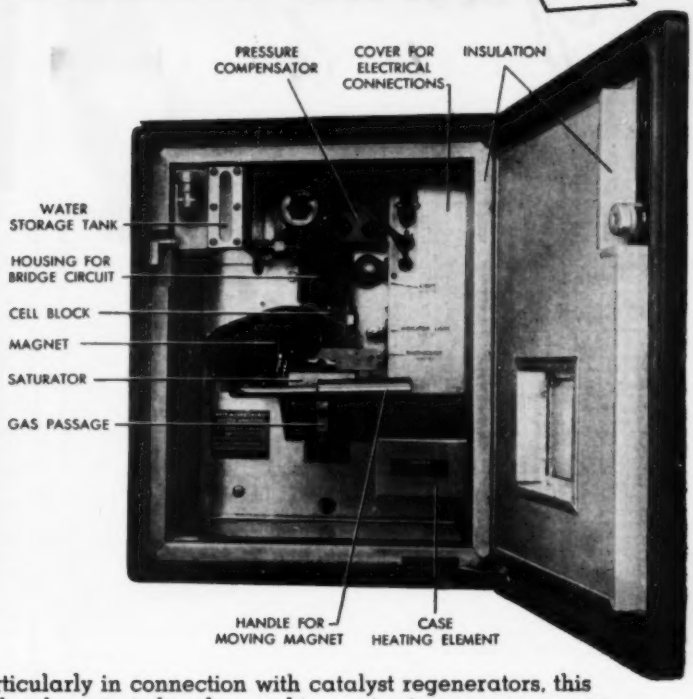
WALWORTH

valves and fittings

60 EAST 42nd STREET, NEW YORK 17, N. Y.

Here's the accurate, dependable OXYGEN METER that the oil refineries have been waiting for

The **HAYS MAGNO-THERM OXYGEN ANALYZER**



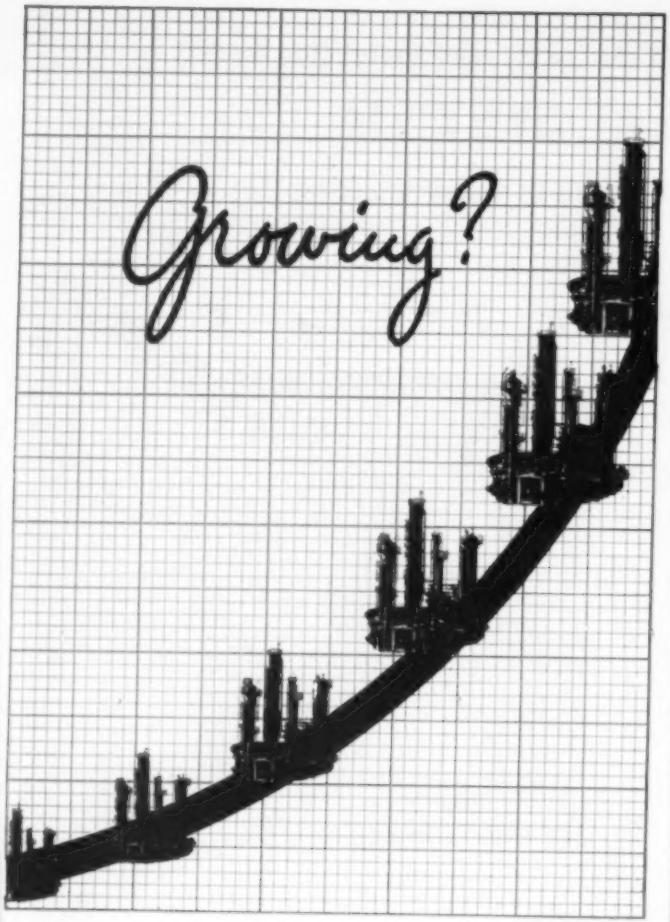
Particularly in connection with catalyst regenerators, this Oxygen Meter has been tested and proved in service to measure oxygen with sustained accuracy and dependability.

Operates on an entirely new principle based on the paramagnetic property of oxygen. No combustion required—no fuel has to be added. Temperature of gas analyzing cell is too low to support combustion, which is a strong safety feature.

One large refinery superintendent says, "After testing several oxygen meters, we find the Hays meter to be operating on the best principle. We like its simplicity, its design, its method of operation, and its rugged construction."

The interesting story of the Hays Oxygen Meter, including the electronic type recorder, is told in Bulletin 48-829. Write for it today.

The HAYS CORPORATION
Since 1905 COMBUSTION & INDUSTRIAL INSTRUMENTS & CONTROL
MICHIGAN CITY, INDIANA, U.S.A.



• Continued growth through improvement of both processing facilities and product quality ...this is the end toward which most refiners are working today . . . the end which many are achieving with the aid of the complete service offered by Universal Oil Products Company.

UOP

Frontier Throughput Up Nine Times Since 1940

By M. H. Robineau
Pres., Frontier Refining Company

In 1940 we founded the Frontier Refining Company as owners and operators of a small skimming plant on the outskirts of Cheyenne, Wyo. In our first year of operation, the daily crude oil throughput averaged 1,275 barrels.

M. H. Robineau

Today, after a consistent program of expansion and improvement carried out with the cooperation of Universal Oil Products Co., our daily throughput is approximately 11,000 barrels—nearly nine times that of our first year.

Total production of gasoline in 1940 was 7,576,000 gallons; in the year ended May 31, 1948, it was 56,500,000 gallons, and in addition, we produced other and readily marketable products.

Succeeds Marketing Company

Frontier Refining Co is the successor to Western Nebraska Oil Co. established in 1925 to market gasoline and other petroleum products to consumers in the small towns and on farms and ranches in the western part of the State. As the marketing business grew, the acquisition of an assured source of product supply became more and more desirable. Frontier became such a source.

Having placed our refinery in operation, our next objective was to increase the efficiency and economy of its operations and to improve the quality of its products. One of our first moves in that direction was to call in Universal Oil Products Co.

The result was installation of a UOP thermal cracking unit with a design capacity of 750 barrels per day which was placed in operation in the summer of 1941 and which has been in successful operation since that time.

War Record

Frontier has a war record of which we are all proud. Immediately after Pearl Harbor, we again called in Universal and worked out plans which were subsequently approved by the Petroleum Administration for War. These plans called for the installation of a separate aviation gasoline refinery employing the most effective processes and techniques to convert products derived from Rocky Mountain crude into components of 100-octane gasoline.

All elements of this refinery were designed and engineered by UOP. Prominent among them was a fluid catalytic

(Advertisement)

cracker of unique design. Many of the costly parts which had been incorporated in the earlier fluid units were eliminated to effect important savings in construction costs. Other processes in the aviation gasoline plant were UOP hydrogen fluoride alkylation, UOP butane isomerization, gas concentration and UOP thermal reforming.

This plant, which was built as speedily as the necessary materials could be obtained, was located on a site adjacent to the existing refinery, so that gases produced by the thermal cracking unit and other facilities in the Frontier plant could be readily transported to the new units as raw materials for the production of 100-octane gasoline components.

The new facilities, which were owned by the Defense Plant Corporation and operated by the Frontier organization, went into service on Feb. 22, 1944. Between that date and Aug. 15, 1945, the plant delivered more than 30,000,000 gallons of high octane aviation gasoline.

Government Plant Purchased

At the close of the war, we assumed operation of the new government plant on a rental basis and used it to manufacture high quality commercial gasoline until the spring of 1947 when we purchased the facilities outright.

A program of converting and improving the combined refineries was undertaken at once and is still in progress.

Among the many projects either completed or under construction at this time, are a catalytic polymerization unit, a new vacuum unit, a new thermal cracker, road oil and asphalt blending facilities, new boiler plants and loading docks, a steam line connecting the two plants, and a Unisol treating unit. Storage facilities have been expanded in several instances.

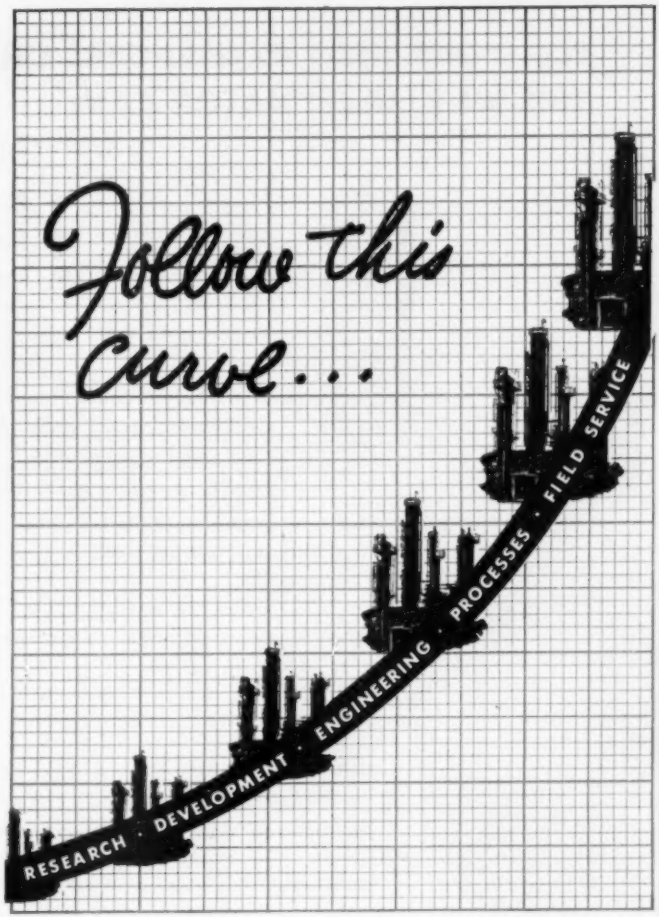
Valuable assistance has been received from Universal Oil Products Co., both in negotiating the purchase of the government plant and in its conversion to peacetime operation, as well as in the designing and engineering of the new facilities.

Drilling and Marketing

In addition to our program of plant improvement and expansion, we have, for the past several years, pursued an aggressive campaign of exploration and drilling. This already has achieved considerable success and it is hoped that it will eventually make Frontier entirely self-sufficient as to crude supply.

Our sales organization is currently marketing "Rarin'-to-Go" brand gasoline and certain other products in Wyoming, western Nebraska, South Dakota, Colorado, Utah and Idaho. While a few bulk plants and retail outlets are company-owned, the independent jobber is the backbone of the Frontier marketing structure. Road oils and asphalts are marketed in Nebraska, South Dakota, Wyoming, Colorado, Minnesota and Wisconsin.

(Advertisement)



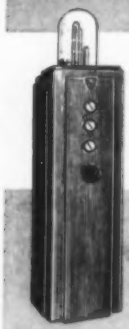
• Graphically, it is the curve of sound, steady growth based on Universal service . . . a service that combines a thorough understanding of processing operations with the ability to translate this understanding into profitable action for the refiner.

UNIVERSAL OIL PRODUCTS COMPANY

UOP General Offices: 310 S. MICHIGAN AVE., CHICAGO, ILLINOIS, U.S.A.
LABORATORIES: RIVERSIDE, ILLINOIS

Universal Service Protects Your Refinery

FOR YOUR HEAT EXCHANGERS OR CONDENSERS, THIS W&T CHLORINATOR CAN:



- Reduce down time
- Cut operating costs
- Improve heat transfer

The machine shown is a W&T Visible Vacuum Chlorinator for the application of chlorine to cooling water circuits through the W&T De-sliming process. Its design is the result of over thirty-five years of pioneering in chlorination, plus the accumulated experience of thousands of installations throughout the world.

Because of the care put into its design and construction, this chlorinator can do these things economically and dependably:

REDUCE DOWN TIME and eliminate costly plug cleaning by ridding condenser tubes of bacterial-induced slime growths.

CUT OPERATING COSTS by keeping condensers and other heat exchange equipment in service longer without shut-down and, at the same time, give higher operating efficiencies.

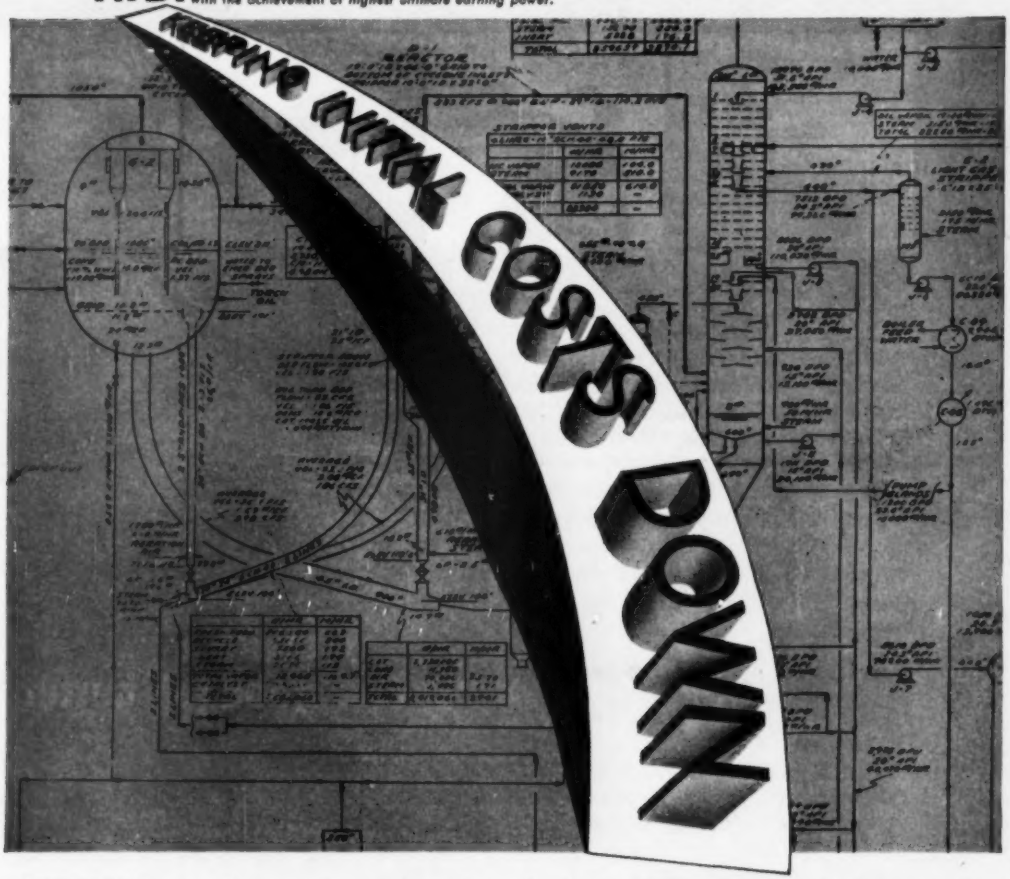
IMPROVE HEAT TRANSFER by keeping water-side surfaces continuously protected against the formation of a slime layer.

For complete information on how these advantages can go to work for you, write today. There's no obligation.

WALLACE & TIERNAN
PRODUCTS, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
Belleville 9, New Jersey • Represented in Principal Cities

CD-30

N.B. While it is axiomatic that *return on investment*—the *ultimate earning power* of a refinery unit when actually on stream—is the only true evaluation of competitive engineering recommendations, *initial plant costs* remain a major factor in refiners' decisions on plant installations. M. W. Kellogg takes specific steps to *minimize initial plant costs* consistent with the achievement of *highest ultimate earning power*.



KELLOGG starts to keep costs down at the precise point where a refinery project starts . . . in process design. For it is the quality of work in the design phase that establishes not only the ultimate earning potential of the unit but also the framework on which initial costs are predicated.

Quality of process engineering is, of course, dependent on the relative ability of individual engineers, their resources in data and experience, the emphasis put on process design by management . . . and, in the final analysis, on the organizational set-up within which the engineers work. Beyond the marked advantages Kellogg can show on the first three factors, its organizational set-up definitely assures *superior quality* in process engineering.

Continued and constant specialization by groups of engineers on every phase of petroleum processing is the keystone of this superiority. Only the volume of business that Kellogg enjoys permits the maintenance of an engineering organization numerically large enough to enable such specialization. The improvement in quality of engineering thus achieved needs no documentation . . . it is as obvious in refinery engineering as in every other branch of technical endeavor.

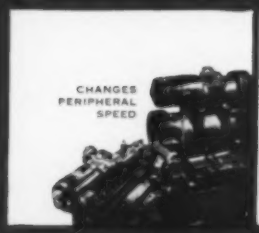
Superiority in process design is only the first in the continuing series of specific steps taken by Kellogg in the direction of low initial plant costs . . . a succession of individually significant contributions that accumulate substantial savings as each project moves through Kellogg's integrated organization.

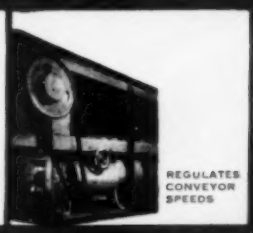
THE M. W. KELLOGG COMPANY

A SUBSIDIARY OF PULLMAN, INC.

ENGINEERS TO THE PETROLEUM INDUSTRY

NEW YORK JERSEY CITY LOS ANGELES TULSA HOUSTON TORONTO LONDON PARIS





These are only a few of the many, many types of applications where Master Speedrangers can help you do a better job. These Speedrangers with their stepless variable speed operation assure exactly the right speed for every operation . . . for each operator . . . the right speeds for each change in the consistency or shape of the material being processed. Such variable speed operation gives you plus value in higher rates of production, a better quality product and more efficient performance of your equipment and your operators.

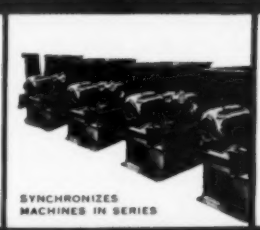
Master Speedrangers provide this infinitely variable speed in compact, all-metal, mechanical variable speed units in a wide range of types and in sizes up to 5 horsepower.

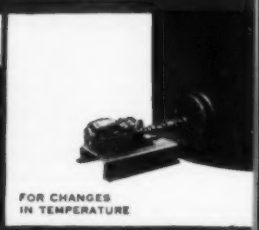
make a good job better

An extra feature of Master Speedrangers is their extreme flexibility, for they can be made to incorporate an electric motor, a variable speed unit, a gear reduction unit and an electric brake . . . all standard Master units that easily combine into a compact, integral power package. This provides exactly the RIGHT horsepower, the RIGHT range of speed, the RIGHT features, in a unit that you can use RIGHT where you want it.

Write for Data 7525, a new 24-page book on Speedrangers, and see what a real job they can do for you.

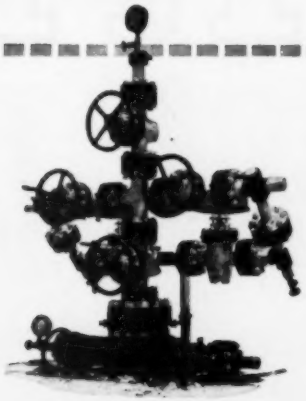
THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO





MASTER SPEEDRANGERS

FROM WELL HEAD to FINISHED PRODUCTS

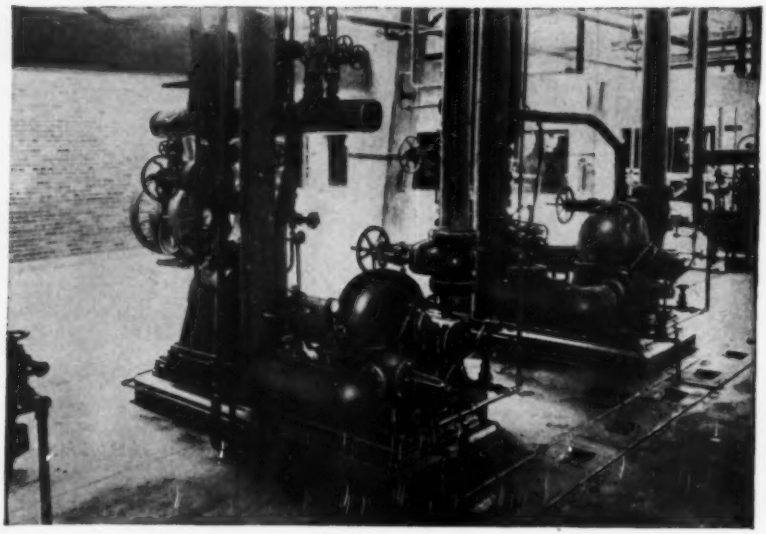


Our work for the process industries includes engineering design and construction of a wide range of installations for natural gas, refining and chemical operations from well head to finished products.

STONE & WEBSTER ENGINEERING CORPORATION

A SUBSIDIARY OF STONE & WEBSTER, INC.

TERRY



THE ROTORS OF THESE 75 H. P. TERRY TURBINES ARE DOUBLE RIM PROTECTED

The two 75 H.P. Terry Turbines shown above (in the plant of a leading refiner) employ the Terry Solid Wheel Rotor. The wheel is made from a single steel forging and the buckets are milled directly into the wheel. — All as shown in the illustration at the left.

The buckets are protected by rims at the sides of the wheel. These rims would take without damage any rubbing that might occur if the clearance became reduced.

With this construction it is impossible for the blades to foul and frequent inspections of the thrust bearing are not required to obtain safe and dependable operation.

This feature and many others of the Terry Wheel Turbine are fully discussed in our Bulletin S-116.

T-1169

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

Any Style
We furnish over 150 styles of bubble caps, without die cost. Other styles promptly designed.
Any Alloy
This enables us to furnish you bubble caps to meet any specific corrosion or coking problem.
TWO BIG CHOICES
Which Are Making Pressed Steel Co.
Bubble Caps the More Widely Chosen

THE fact that 60% of the oil industry's fractionating equipment are today using bubble caps by The Pressed Steel Co. points up the effective way in which we are helping our customers solve their problems.

First, we have dies for over 150 different styles of bubble caps, both round and rectangular. As a result we not only make prompt delivery, but we save many customers the cost of dies. Caps to meet special requirements will be promptly designed by our engineering department.

LESS COKING, FEWER CLEANOUTS

Another feature of our manufacturing service is that we fabricate bubble caps from the entire and complete list of alloys which are available today. Tell us your coking and corrosion problems, or any other conditions faced in your towers. We will then select the one alloy that best meets them. Because bubble caps by The Pressed Steel Co. are "alloy right", they obviously result in fewer cleanouts and more on-stream hours—as evidenced by plant records.

LET OUR TECHNICAL STAFF HELP YOU

In addition to the two broad advantages described above, The Pressed Steel Co. offers you a wealth of experienced engineering assistance and production know-how, gained through the almost quarter-century we have been supplying welded alloy equipment to the refining industry. Send blue prints or write as to your needs. The services of our technical staff are freely available. Also welded tubing, conveyor flights, etc., in sheet alloys to any specifications.

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

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Now YOU CAN SELECT A TURBINE

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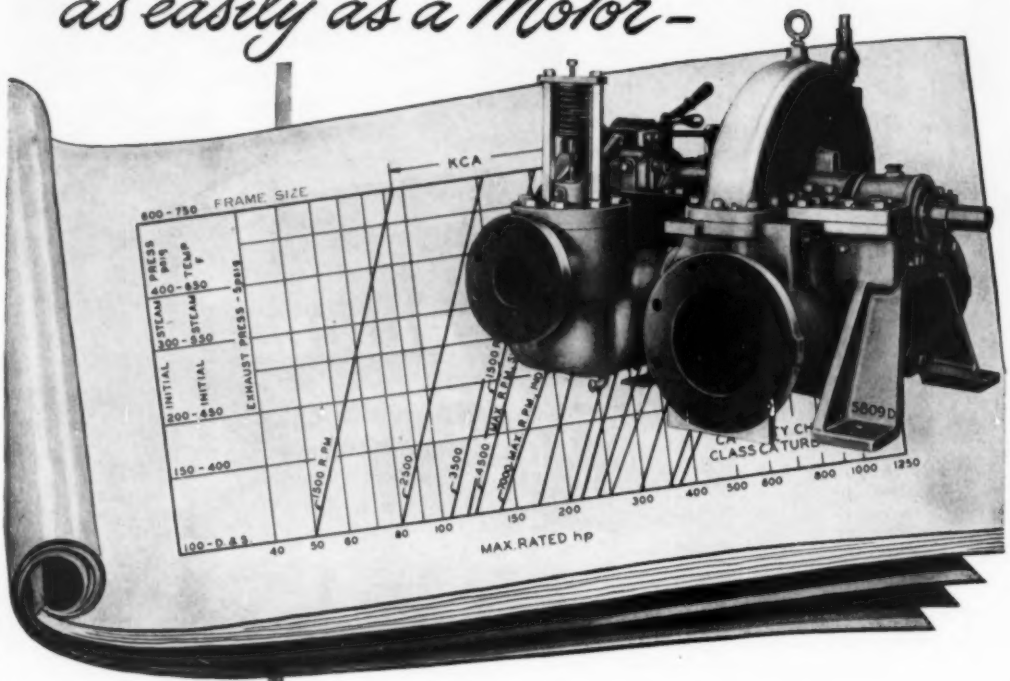

SIMPLIFIED RATINGS FACILITATE SELECTION OF NEW DE LAVAL MECHANICAL DRIVE TURBINES

Because of the great demand for the reliability, speed variability and economy inherent in mechanical drive steam turbines, the De Laval Steam Turbine Co. has designed a new standardized line of velocity stage turbines, manufactured these units in quantity for prompt delivery, and published simplified rating tables that make the preliminary selection of the right turbine size as easy as the selection of an electric motor.

Send for catalog describing the new and improved De Laval Class CA velocity stage steam turbine for mechanical drives.

DE LAVAL

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T-13

TURBINES • HELICAL GEARS • WORM GEAR SPEED REDUCERS • CENTRIFUGAL PUMPS • CENTRIFUGAL BLOWERS AND COMPRESSORS • IMO OIL PUMPS

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CORROSION-PROOFED *Solderless* TERMINALS

Protect electrical connections against CORROSION!

Hydrogen Sulfide, Sulphur Dioxide, Ammonia, Butane, Hydrochloric and Sulphuric Acid fumes have no measurable effect on AMP Corrosion-Proofed Terminals. Where precision of operation must be maintained under corrosive conditions the AMP Corrosion Proofing Method has proven itself.

AMP corrosion proofing prevents indefinitely any measurable increase of resistance of the terminal due to corrosion.

AMP corrosion proofing actually increases the electrical conductivity of the connection.

AMP corrosion proofing is self-healing, for it re-forms over any break or abrasion.

AMP corrosion proofing has creeping properties which cover any exposed portion of the wire making a continuous metallic joint without interface, thereby assuring a continuous corrosion resistance for the entire connection.

AMP corrosion proofing can be applied to any AMP copper terminal. Thus the PRE-INSULATED or uninsulated terminal installation can be AMP corrosion proofed.

AMP

PRE-INSULATED "Diamond Grip" Solderless Terminal

Precision of operation requires uniformity of terminations. AMP meets this requirement with the Certi-Crimp hand tool. A special ratchet device does not permit the tool to open once the crimping operation is started until that operation is complete — no chance for error — the human element of chance and fatigue is eliminated.

All items covered by Pats. or Pats. Pending

AMP Solderless Terminals + AMP Corrosion Proofing + AMP Tooling = **"Precision Engineering Applied to the End of a Wire"**

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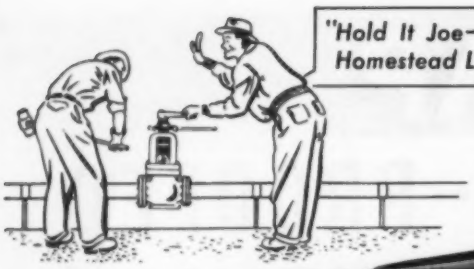

Homestead
LEVER-SEALD
Valves

**ALWAYS WORK
LAST LONGER
COST LESS PER YEAR**

STICKING valves are never a problem with Homestead Lever-Sealds on the job. Built into each valve is a powerful leverage, ready at all times to overcome the effects of corrosion, viscous fluids or temperature and pressure extremes which cause ordinary valves to stick or "freeze."

This powerful leverage not only relieves pressure between the seating surfaces to permit operation under all conditions; but it also is the means of providing the extra tight seal against leakage—the seal which keeps corrosive or erosive line fluids away from the seating surfaces; assures longer valve life and lowest cost per year.

Made in stainless steel, steel, semi-steel, bronze, monel or other alloys suitable for the working conditions under which they are to be used, Homestead Lever-Seald Valves may be had in sizes from 1" to 12"; and for working pressures from 150 pounds to 1500 pounds.

Choose the sizes and types for your services from Reference Book 39 Section 3. Write for your free copy today.

Check these Outstanding Features:

A QUARTER-TURN fully opens or closes valve.

INSTANT STICK-PROOF OPERATION. Plug turns freely after seating pressure is relieved by screw lever.

POSITIVE LEAKLESS SEAL is obtained by applying full seating pressure with screw lever after opening or closing.

LEAK PROOF. Deep stuffing box, gland and sealed bottom prevent fluid loss, and reduce hazards.

STRAIGHT-LINE FLUID FLOW. Little or no pressure drop.

SEATING SURFACES ALWAYS PROTECTED in both open and closed positions. Fluid or grit cannot damage valve seat.

HOMESTEAD VALVE MANUFACTURING CO.

P. O. BOX 16 CORAOPOLIS, PENNA.

Versatile...

in more ways than one

Elliott BLOWERS

may be installed with the blower discharge in any one of 48 positions (24 positions, 15 degrees apart, for each direction of rotation). This is typical of the general versatility of Elliott blowers which can be built to meet all kinds of demanding conditions and requirements.

Their construction is particularly adapted to combating the difficulties of handling corrosive gases. The impeller and all stationary parts in contact with the gas can be made of material which will minimize corrosion. In addition, the inherent design of the open type, one-piece, radial blade impeller is such that deposits cannot easily accumulate to cause corrosion or to produce unbalance.

Versatility of drive is furnished by the choice of an Elliott steam turbine or electric motor.

Smooth-running, efficient Elliott units are setting records for non-stop operation and extraordinary service in oil refineries, in sulphuric acid plants, and for many other services in the chemical and process industries.

Write for Bulletin RP-7
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Technical Data Dept.
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P-1080

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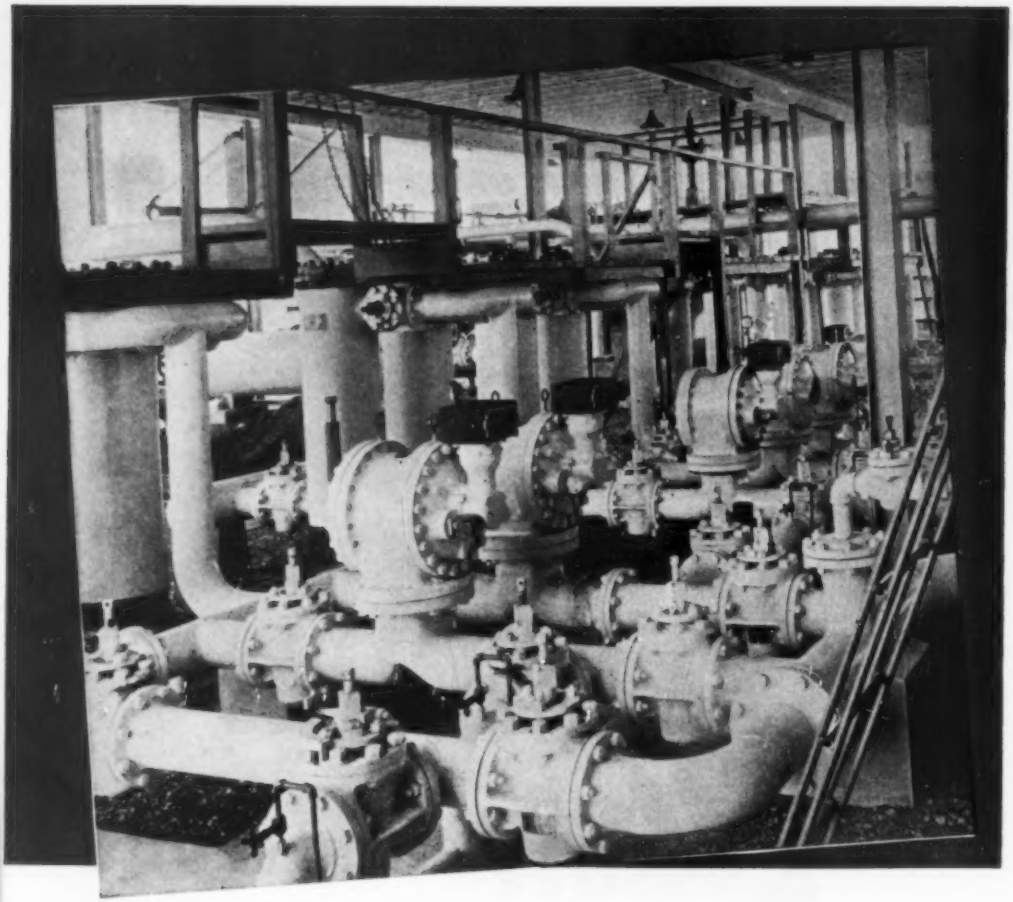

Always safe and never sorry

You can be sure of one thing about engineers who lay out product piping. They play safe! And there you have reason No. 1 for widespread use of the No. 1 brand of welding fittings by the petroleum industry.

In pumping stations and other places where high pressures, temperatures, and various critical factors prevail, Tube-Turn welding fittings are used. Their butt-welded joints simply can't leak. Foolproof strength in the fittings themselves is insured by the nation's top welding fittings manufacturing experience.

Too, the smooth inner walls and smoothly functional design of Tube-Turn welding fittings reduce friction, pressure loss, erosion. Their dimensional accuracy speeds piping assembly.

Deal with the Tube Turns distributor for good connections—and good service. He handles the biggest line of welding fittings.

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WELDING FITTINGS AND FLANGES

Write for booklet of tables, "Allowable Working Pressures of Tube-Turn Welding Fittings."

LOOKING FOR A REAL BARGAIN IN ... *fractionation?*

You can't afford to overlook Koch Kaskade trays and their application to your fractionating and absorption needs. Because they give higher yields and cleaner separations at lower cost, Koch Kaskade trays have made the bubble tray obsolete and costly.

We'll be glad to give you specific operating experiences of present users, and show also how Koch Kaskade trays will improve your present fractionating facilities . . . without obligation, of course. Write or wire us today.

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ROCKWOOD'S new ball type VALVE

Check for yourself these outstanding features that make the Rockwood Ball Type Valve the *best buy* in valves. Rockwood Valves already have proven to plant superintendents, engineers and maintenance men that they are easier to operate, last longer, give longer leak proof service — also increase the output of materials handled. Hundreds of these valves are now operating on pipe lines handling water, air, gas, solvents, acids, paints, varnishes, food, paper fluids, petroleums and many other liquids and gases.

Available in bronze with screwed ends in all pipe sizes from ½" to 2".

For more information, write for folder V-4.
Distributors in all principal cities.

• Quick opening and closing —

A quarter turn (90°) of the Rockwood Ball Valve control handle will give full opening to full closing. This same handle is designed so that it can be mounted in four different positions assuring clearance in all types of installations. It can also be removed and a "T" handle used wherever remote operation is necessary.

The fast, smooth, easy operating action of this handle will help speed up production and increase worker efficiency.

• Leak proof Service —

Every Rockwood Ball Valve is constructed with a floating bronze ball that is hard chromium plated, making it extremely resistant to pitting, scratching and abrasion. This ball in combination with the *resilient synthetic rubber seat* forms a tight seal when valve is in open or closed position. Rubber seat allows particles to be *automatically* wiped clear of seating surface when valve is opened or closed without injury to ball or seat.

Pressure of fluid stream automatically positions ball against rubber seat — prevents leakage.

• Full round flow —

The full round port area of the floating ball does not permit your fluid stream to change — creates no turbulence in the stream, thus friction loss is reduced to a minimum.

You get greater production at lower cost with the full round flow feature of the new Rockwood Valve.

RECOMMENDED FOR 300 P.S.I. WORKING PRESSURE.

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FOR DIFFICULT GAS CLEANING PROBLEMS

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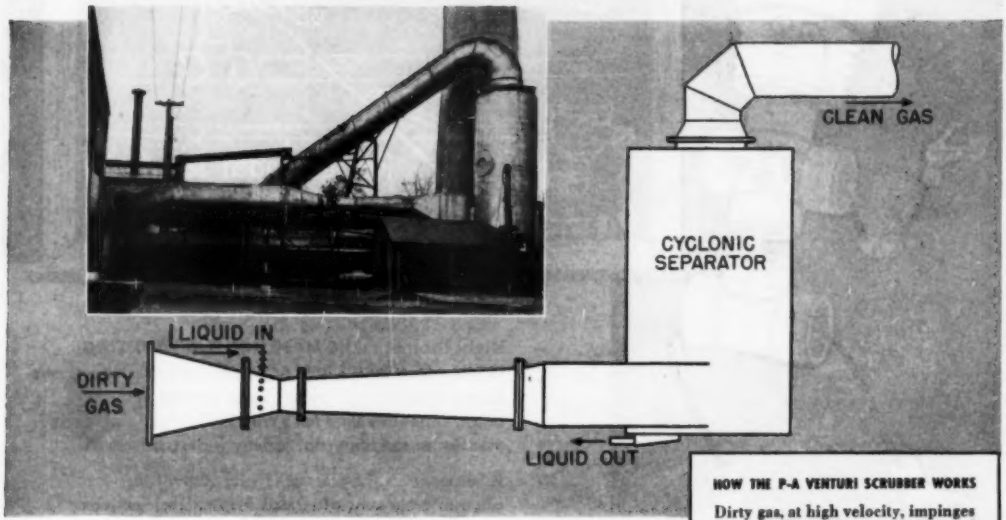
The P-A Venturi Scrubber

(A PEASE-ANTHONY DEVELOPMENT)



HOW THE P-A VENTURI SCRUBBER WORKS

Dirty gas, at high velocity, impinges upon and atomizes a curtain of liquid introduced through jets at the throat of the Venturi. Differential velocities of gas and atomized liquid result in collision of mist or dust particles with liquid droplets. The coalescence of mist or agglomeration of dust resulting from this collision makes simple cyclonic separation possible.

APPLICATIONS: The P-A Venturi Scrubber is a highly effective and economical apparatus for solving such major industrial problems as: SMOKE ABATEMENT · REMOVAL OF DUST AND MIST FROM GASES · RECOVERY OF VALUABLE METALS AND CHEMICALS.

ADVANTAGES: Highly efficient—Assures virtually complete removal even of sub-micron dust and mist.

Low initial cost—The first cost of the P-A Venturi Scrubber is considerably less than other equipment of equivalent performance.

Low Maintenance — Its maintenance cost is less than that of other equipment of equivalent performance.

Low Water Requirement — Requires generally less water (or scrubbing liquid) than other liquid scrubbers.

Can Handle Gas At Any Temperature—Pilot Plant tests show no difficulties even at 1800° F. Actual installations now operating at 700° to 800° F.

More Compact and Lighter—It requires less space and is lighter in weight than other equipment of equivalent performance.

Simple and Safe to Operate and Maintain—Any competent maintenance man can service a P-A Venturi Scrubber. No special skill is needed to repair equipment.

Chemico's engineering background and development facilities combined with Pease-Anthony's experience in gas scrubbing offers highly qualified service in this field.

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Chemico Plants are profitable investments

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FORGED FITTINGS LAST

Right Professor. ***THE MAJOR COST OF A FITTING IS THE COST OF ITS REPLACEMENT.*** And the life of one *forged* steel fitting is many times greater than that of any other fitting. That's why W-S *forged* steel fittings cost less in the long run, for any industrial service.

If someone in the class asks why, show him photomicrographs of etched forged steel sections. He'll see compact metal structure which resists vibration-fatigue and corrosion. He'll see uniform grain, free of cracks and pockets.

Tell him, too, they're smaller and lighter, size for size and service for service, than most cast types having only a fraction of their pressure rating.

Available? PDQ from W-S distributors in all principal cities.

WATSON-STILLMAN

ROSELLE, NEW JERSEY

Designers and Manufacturers of Forged Steel Fittings, Valves, Wire Rope Shears, Hand Pumps, Jacks, Pipe Benders and Hydraulic Equipment

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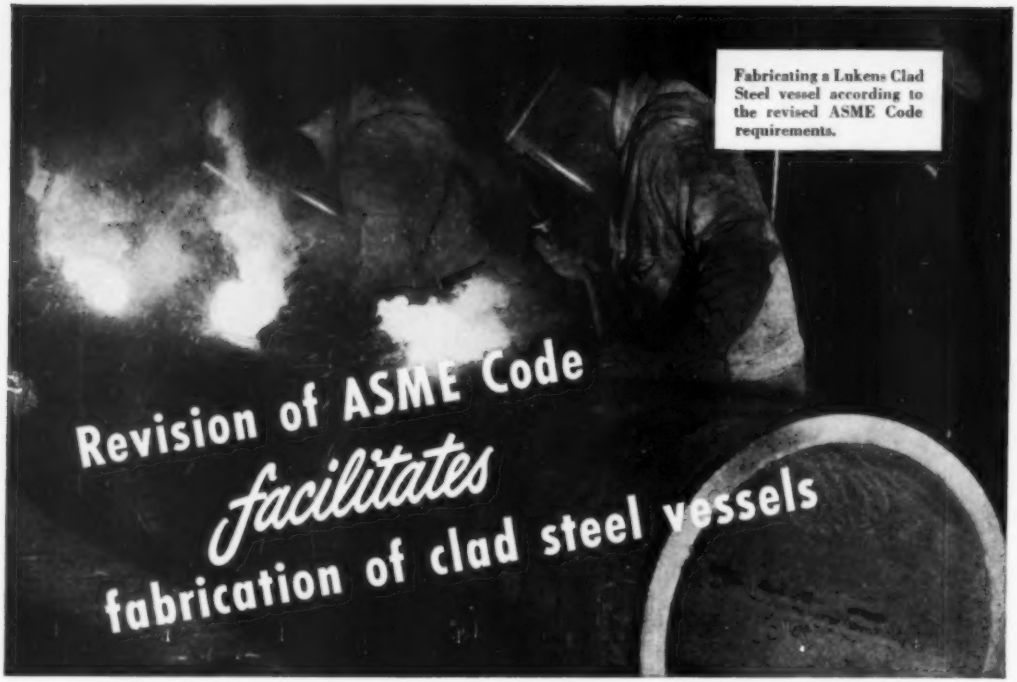

Fabricating a Lukens Clad Steel vessel according to the revised ASME Code requirements.

As announced recently in Mechanical Engineering, Case 896 of the ASME Code has been further revised. Rulings cover welding procedure and operator qualification requirements, with the result that, in many cases, the fabrication of clad steel equipment is facilitated and speeded up.

All-alloy welds can be used throughout the entire section of a clad steel shell where the small diameter, for example, makes this necessary. Materials meeting Specification SA-263, Grade A (Type 410) can be used without stress relief if the carbon content of the cladding is less than 0.08. Temperature limitations for certain types of clad metals have been modified.

Case 1078, covering the use of linings which are applicable to certain fittings—manways, nozzles and the like—is also now available for the first time.

For general information on Lukens Nickel-Clad, Stainless-Clad, Inconel-Clad and Monel-Clad Steels, write for Bulletins 255 and 338. Lukens Steel Company, 404 Lukens Building, Coatesville, Pennsylvania.

CLAD METAL STEEL

LUKENS

Nickel-Clad Stainless-Clad
Inconel-Clad Monel-Clad
STEELS

SOLID METAL ADVANTAGES WITH CLAD STEEL ECONOMY

• • SPEED SCRAP TO THE MILLS TO MAKE MORE STEEL • •

TO ALL

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GREETINGS

from the

NATURAL GASOLINE SUPPLY MEN'S ASSOCIATION

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decreased coking troubles
no salt plugging, less HCL corrosion
full use of maximum refining capacity

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PETRECO Electric DESALTERS assure maximum salt removal, because they are kept at top efficiency through PETRECO SERVICE, which also provides

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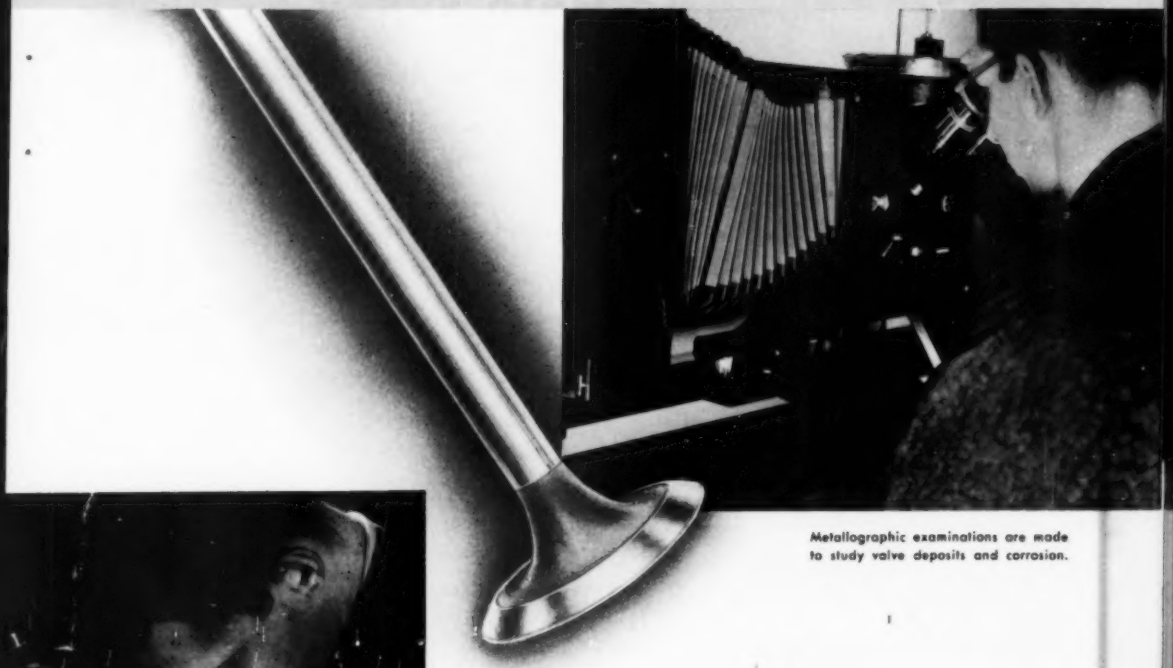
PR 49-3

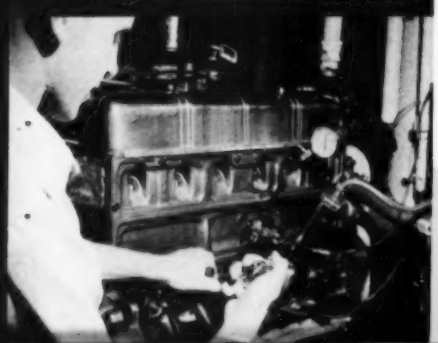
DUPONT TETRAETHYL LEAD COMPOUNDS



Metallographic examinations are made to study valve deposits and corrosion.

Examining surface condition of valve.

Checking compression pressures to determine condition of valves undergoing test.



Du Pont Research

at work on the problem of prolonging valve life

The ultimate objective of all Du Pont research on tetraethyl lead and other anti-knock agents is the improvement of fuel performance and fuel utilization. Starting point for this research is a better understanding of the action of fuels in internal combustion engines.

One such study of broad significance is devoted to investigating the effect of combustion on engine valves. Exhaust valves, especially, have always presented certain problems in design and operation because of the severe conditions under which they must operate. The many variables of fuels, lubricants, design and operation which can affect valve life are being investigated.

This is another example of Du Pont research at work on problems of mutual interest to the refiner and automotive manufacturer.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

Research... To Help Every Refiner

In the present valve investigations, Du Pont chemists, engineers, and metallurgists are seeking answers to the problem of improved valve life. Fundamental studies of valve corrosion and deposits as well as the many other factors that can affect valve operation are being made.

This and other Du Pont research projects are aimed at gathering information on problems of vital concern to all refiners, information which will also contribute to better fuel additives and improved fuel quality, today and in the future.

Metallographic examinations are important in the study of valve deposits and corrosion. The photomicrographs below are a few made in the course of these studies.

DU PONT
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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

MAKE DUPONT THE SOURCE FOR ALL OF YOUR GASOLINE ADDITIVES . . .

- *Tetraethyl Lead Compounds*
  Aviation Mix—Motor Mix
- *Antioxidants*
- *Metal Deactivator*
- *Dyes*

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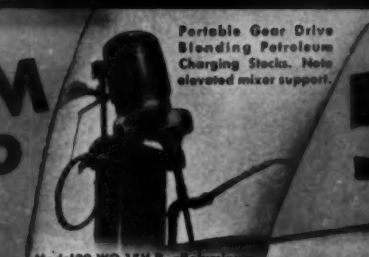

Portable Gear Drive Blending Petroleum Charging Stocks. Note elevated mixer support.

Model 30-WQ-15 H.P., all aluminum construction — one of 4 installed on 45,000 gal. aluminum tank.

SEG-25 H.P. on 100,000 bbl. Butane blending tank.

Lightnin Portable Direct Drive used for blending small quantities of light liquids.

AND ALL QUANTITIES IN BETWEEN

SAG Side Entering on 100 octane gasoline blending tank.

Three SAG units installed on 5,000,000 gallon gasoline blending tank.

with LIGHTNIN & MIXCO MIXERS

When your process involves the agitation of liquids, regardless of tank size, a Lightnin or Mixco Agitator will do the job at the lowest possible initial and operating costs. And every mixer is specifically adapted and recommended for each individual job.

Mixing Equipment Company's unparalleled know-how, gleaned from thousands of mixer applications, is back of every recommendation. This valuable experience can save you time and money—it's yours for the asking. Just tell us what your mixing problems are. Your inquiry will receive prompt attention.

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STEAM-EX

Changes Air in a 100,000 Barrel Tank *in 2 Hours*

When you wish to gas-free a petroleum storage tank, or a marine tanker compartment, so that workmen may safely enter for interior cleaning, inspection or repair—**Time is of the essence.** The S. & J. STEAM-EX shown here is a high volume ejector that will do this job quickly and economically.

With steam at 75 lbs. p.s.i. the STEAM-EX uses only 900 pounds per hour. With compressed air at 100 lbs. p.s.i. it takes 200 cu. ft. per minute. With either steam or air under the conditions above, the STEAM-EX will displace 300,000 cu. ft. per hour. This means that you get a complete change of air in a 100,000 barrel tank every two hours.

Gas-freeing a tank with the STEAM-EX is a simple operation. You install the exhauster over a 20" manhole on the tank top, connect up your steam or air hose or piping, open up all bottom manholes and turn on the air or steam. Dangerous gases are dissipated to the atmosphere at an almost incredible speed, compared with previous methods of accomplishing the same results. Descriptive folder and prices will be mailed on your request.

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S&J

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Petro-Chem Iso-Flow Furnaces

Pre-Eminent

For Multi-Pass Operation . . . .

Uniform heat distribution per pass being a most important essential to efficient operation of multi-pass furnaces, it is significant that Petro-Chem Iso-Flow Furnaces are unequaled for uniform heat distribution per pass because their cylindrical design and vertical tubes provide a perfectly symmetrical pattern on the fluid and combustion sides, regardless of the number of passes required.

Each bank of tubes (each pass) is equi-distant from the flame.

●

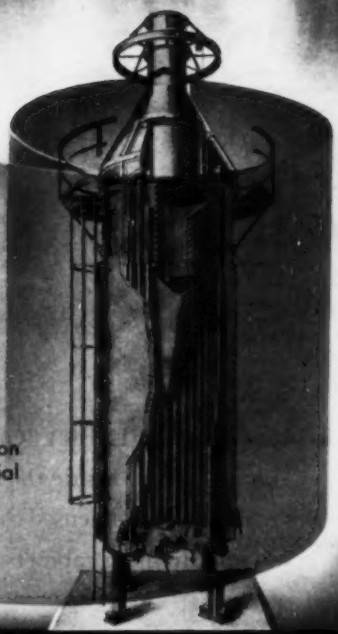
Each bank of tubes (each pass) is exposed to the same heat intensity.

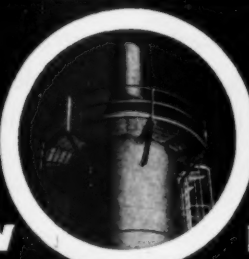
●

Length of fluid travel for each pass (including crossovers) is identical from inlet to outlet.

●

All of the above give the minimum variation in tube wall temperature and are essential for critical high temperature operation.





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SAY "CHASE ANTIMONIAL ADMIRALTY"

It could well mean a great saving to you.

You see, the minimum percentage of antimony set forth in Chase Patent No. 2,061,921 is .007%. Under certain mild exposure conditions this quantity would prove effective. However, experience has shown that a minimum of about .015% is essential to give reasonably complete protection against dezincification under the entire range of conditions.

To assure you this .015% minimum, Chase manufacturing processes incorporate nominally .035% antimony in their admiralty. Why risk tube failures when you can specify *Chase* Antimonial Admiralty, *which costs you no more than plain Admiralty*. Write or call your nearest Chase Warehouse or Sales Office today, listed below.

Special stocks of ANTIMONIAL ADMIRALTY Condenser Tubes in Chase Warehouses: BALTIMORE, NEW ORLEANS LOS ANGELES, SAN FRANCISCO *also carried by*— Vinson Supply Co., Tulsa Standard Brass & Mfg. Co., Houston

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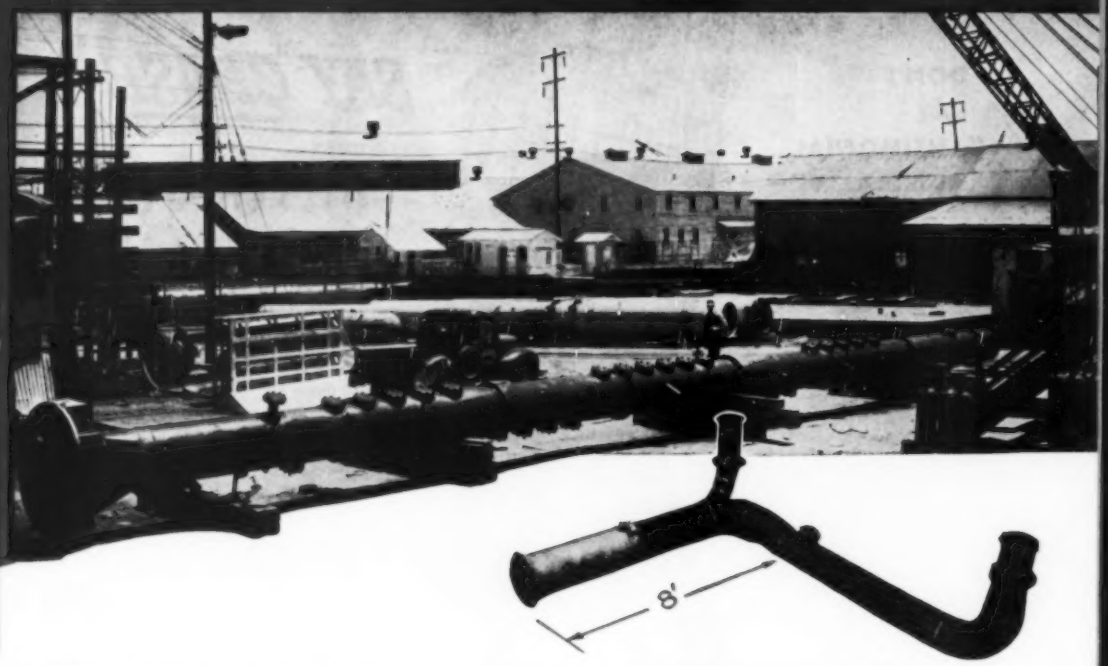

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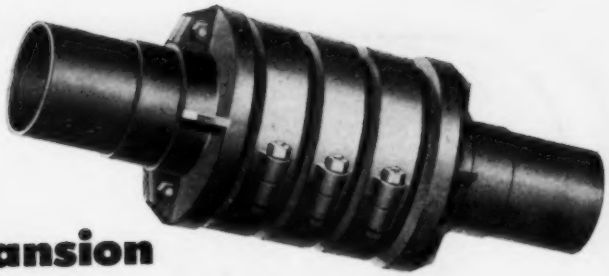

wherever pipeline expansion is a PROBLEM

CMH Expansion Joints are the cost-saving, trouble-saving solution!

Common expansion joint problems of leakage, repacking, space limitation and complicated, costly installations are solved with CMH Expansion Joints. Compact, inline units, CMH Expansion Joints are easy to install—actually, they are standard piping sections. They require *no* maintenance . . . **and they don't leak.**

CMH Expansion Joints are available in either stainless steel or copper . . . Free-Flexing units for pressures up to 30 psi . . . Controlled-Flexing units for pressures up to 300 psi . . . **special units for unusually high pressures.**

Selection of the correct CMH Expansion Joint has been simplified to a matter of charts from which the joints necessary to meet your requirements may be chosen quickly and easily. CMH'S "Engineered Application Service" is also available to assist on unusual installations.

Full data on CMH Expansion Joints including the charts mentioned above are given in Bulletin EJ-49. Ask for a copy.

CMH—ONE dependable source
for every flexible metal hose requirement

• CMH manufactures all standard types of flexible metal hose, both convoluted and corrugated, in a variety of metals; expansion joints for piping systems; stainless steel and brass bellows; various conduits and special assemblies of these components.

CHICAGO METAL HOSE CORPORATION
EXPANSION JOINT DIVISION

Leaders in the Science of Flexonics
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Plants at Maywood, Elgin and Rock Falls, Illinois
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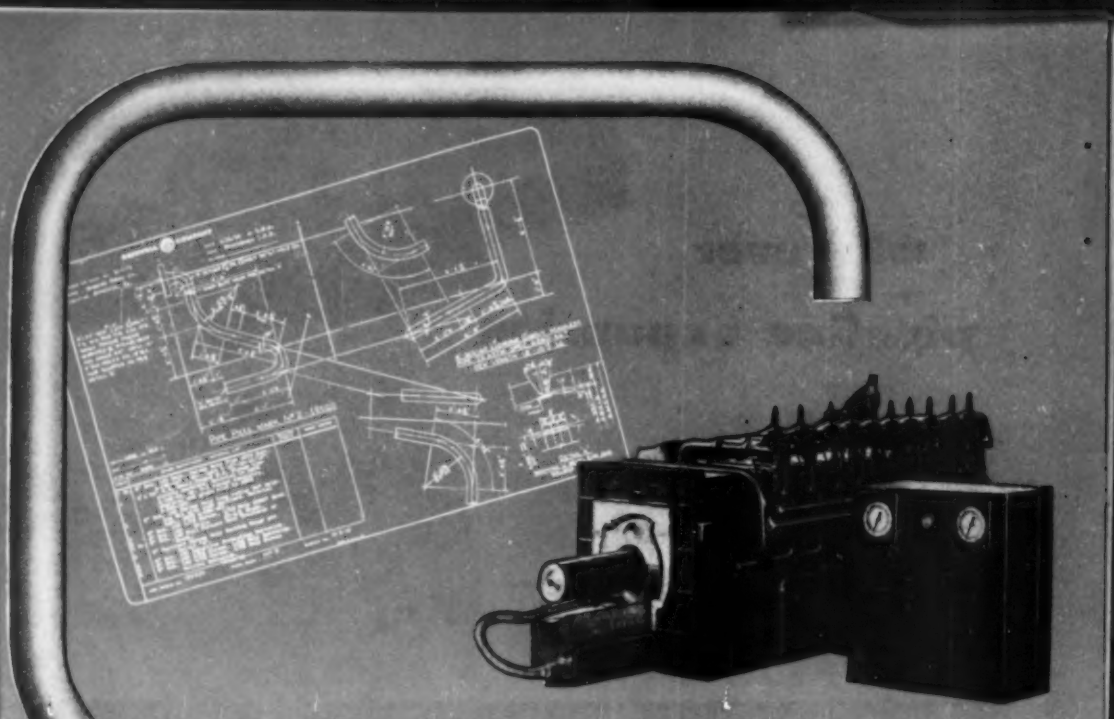
FLEXON identifies CMH products which have served industry for more than 47 years.



Keeping stainless steel STAINLESS

. . . a typical problem in fabricating alloy piping

Heat a piece of stainless steel pipe to bend it and right away you're up to your ears in metallurgical complications. To begin with, stainless steel isn't just one alloy. There are hundreds of different types of stainless steel, each selected for its resistance to corrosion or its stability at high temperatures. To maintain the metallurgical properties which dictate the choice of a particular alloy steel, you have to know the temperature range within which this steel may suffer excessive metallurgical changes. And you have to have specialized equipment to maintain the precise control necessary to avoid these hazards.

Grinnell pipe fabrication equipment includes specially designed gas-fired radiant heat furnaces for this precisely controlled heat treatment of stainless steels and other alloy steels. Multiple burners are strategically located to distribute temperature uniformly and to prevent harmful flame impingement. Precision instruments regulate temperature and time.

It's an intricate business . . . fabricating alloy steel piping. It's a job for Grinnell prefabricating plants because Grinnell has the equipment and modern methods, the interpretive engineering, the metallurgical research facilities and the skilled personnel.

99 YEARS PIPING

GRINNELL

Grinnell Company, Inc., Providence 1, Rhode Island. Branches: Atlanta • Buffalo • Charlotte • Chicago • Cleveland • Cranston • Fresno • Kansas City • Houston
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K&M "*Century*" Asbestos Corrugated

for long life without maintenance...

The "new" roof on this industrial building is actually more than 3 decades old! A coal operator installed these "Century" Asbestos Corrugated sheets on a coal tipple 33 years ago before he re-used them here.

for modern architectural effect...

Beauty in typically modern style is brought to this store with a facade of "Century" Asbestos Corrugated. This beauty will *last* without any painting or other expensive upkeep.

You've probably noticed that "Century" Asbestos Corrugated is growing in popularity for decorative motifs...inside and outside...for industrial plants, stores, restaurants, theaters. There's a rugged attractiveness in the simplicity of the corrugations and neutral light-gray coloring.

And perhaps it's no news to you that "Century" Asbestos Corrugated is thoroughly practical from the *structural* point of view. It actually *toughens* with age. Never needs to be painted. Can't rot, corrode, catch fire, or succumb to termites.

NEW "TOP-SIDE" FASTENERS CUT ROOFING COSTS

On top of all this, you can specify the new "TOP-SIDE" Fasteners, and cut a big slice off the cost of roof installation over steel purlin construction. Exclusive with "Century" Asbestos Corrugated, these new fasteners permit roofing to be done entirely from *atop the roof* ...eliminating entirely the costly labor and scaffolding normally required beneath. This feature, alone, is worth looking into—write us for full details.

Nature made Asbestos... Keasbey & Mattison has made it serve mankind since 1873

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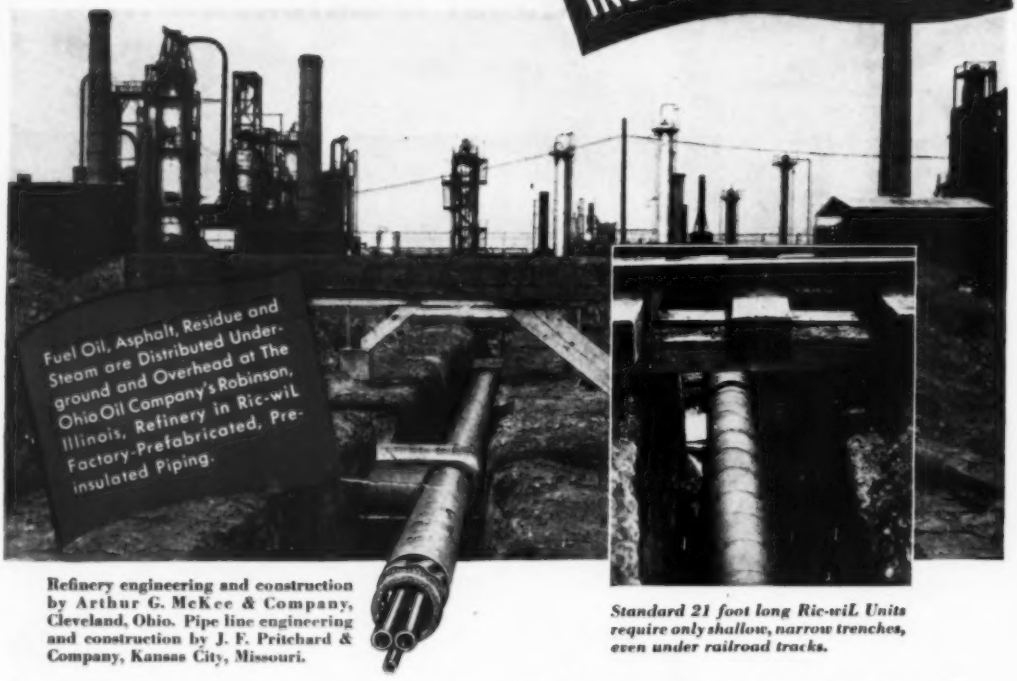
K&M best in asbestos

Oil Refinery Meets Diversified Piping Needs with RIC-WIL

INSULATED PIPE UNITS


Fuel Oil, Asphalt, Residue and Steam are Distributed Underground and Overhead at The Ohio Oil Company's Robinson, Illinois, Refinery in Ric-wiL Factory-Prefabricated, Pre-insulated Piping.

Refinery engineering and construction by Arthur G. McKee & Company, Cleveland, Ohio. Pipe line engineering and construction by J. F. Pritchard & Company, Kansas City, Missouri.

Standard 21 foot long Ric-wiL Units require only shallow, narrow trenches, even under railroad tracks.

● The adaptability of Ric-wiL Insulated Piping Systems to any type of piping requirement is ably demonstrated by this refinery installation. It consists of ten separate runs of prefabricated pipe units employing a wide variety of pipe sizes and pipe arrangements for distribution of steam and viscous fluids at various temperatures.

The temperatures required for the distribution of the various viscous fluids are efficiently maintained in Ric-wiL Uniline Insulated Pipe Units. In this type of construction, pipes carrying oil, asphalt, etc., are nested with a steam tracer inside an insulation liner which insulates them from the exterior but not from each other.

At Ohio Oil, many different viscous fluids are carried in 4″ and 6″ pipes at temperatures ranging from 125° to 400°F. Steam for tracer lines and processing is distributed in pipes of from 1″ to 6″ diameter at 150 psi, 450°F.

Pipes and insulation are housed in helically corrugated, 16 gauge galvanized ingot iron Hel-coR conduit, ranging from 8″ to 21″ in diameter. The inherent flexibility and strength of this conduit permits underground installation with only 3′-5′ cover, even under heaviest ground loads. Overhead installations require a minimum of scaffolding and supporting structures. Units may be connected on ground before being lowered into trench or erected for overhead suspension. Entire piping systems are delivered completely prefabricated with all accessories—elbows, tees, anchors, expansion loops, etc.—ready for speedy, low cost installation.

Ric-wiL manufactures three basic types of Prefabricated Insulated Piping Systems—Hel-coR, Foilclad and Cast Iron Pipe Units. Pipe, insulation, and protective covering are factory-tailored to individual specifications to meet any condition or requirement for outside piping distribution. For descriptive literature, full information write: The Ric-wiL Company, Department 14-D.

"A Cottrell Installed by Research Corporation *will reduce catalyst loss to less than one ton per day"*

The through-put capacity of the cracking unit in the oil refinery was 20,000 barrels per day. The engineer from Research Corporation noted the plant arrangement and type of catalyst to be used and was able to recommend a Research Corporation Cottrell that would keep catalyst losses to less than one ton per day. Actually in some plants the Cottrells have, in effecting the above results, recovered as high as 50 to 100 tons of catalyst per day.

Performance like this is the result of over 35 years of experience combined with careful engineering appraisal, attention to details and a remarkably efficient method. These, combined with equipment which gives recoveries of over 99%, are responsible for outstanding records of recovery.

A letter from you to the Research Corporation will bring an informative bulletin describing HOW the Research Corporation Cottrell Electrical Precipitator performs, and HOW it can bring about important savings. Write for your copy today. RC-107

Research Corporation Installations

47 CARBON BLACK PLANTS
200 METALLURGICAL INSTALLATIONS
203 ACID PLANTS • 34 PAPER MILLS
262 DETARRING INSTALLATIONS
195 POWER STATIONS
71 STEEL PLANTS • 95 OIL REFINERIES
AND MISCELLANEOUS INSTALLATIONS

RESEARCH CORPORATION

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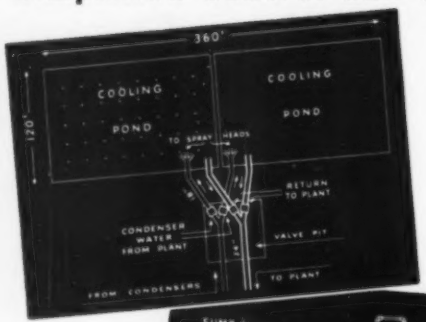
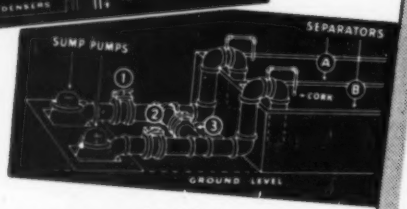
R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •

Simplified Control and Shut-Off





Four 18-inch electric motor operated R-S Valves are controlled by manual switches from the power plant in the condenser water cooling pond installation. This arrangement permits the use of one or both cooling ponds or the draining of either or both.

In the illustration of sump pump discharge, the plant sewer lines drain into the sump where the waste is pumped into concrete separators through R-S Valves 1 and 2. Valve 3 in the connecting line provides a means of cleaning either A or B separators as the ¾ inch syphon breakers can be plugged with corks and the fluid syphoned from the separators to facilitate cleaning operations.

50-pound R-S Iron Valves are utilized in both of these installations. They are designed for rugged hydraulic service with a large safety factor for line stresses, water hammer, and other abuses. Available with 25-pound or 125-pound American Standard flanges, the usual four types of manual control or power controlled prime movers of various types. Furnished in any metal that can be cast or welded including steel with Series 15, 150-pound American Standard flanges.

The angular seating disc gives wedge-type closure. For positive 100% shut-off, these valves can be fitted with the renewable, replaceable R-S patented rubber spool.

Consult the R-S representative in your locality. His experience can be extremely helpful. You will find the address and phone number listed under "R-S Products Corporation, Valves."

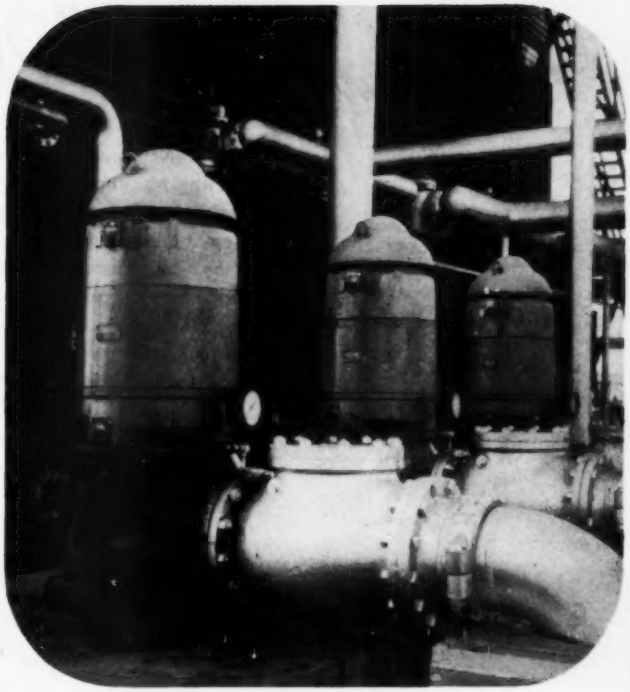
R-S Products Corporation, Wayne Junction, Philadelphia 44, Pa.

R-S Duplex Strainer. 2½ turns of single handwheel permits alternate removal of identical basket strainers without interruption to flow. Valve controls strained water only resulting in reduced corrosion.

No. 709. 50-pound Cast Iron Valve can be equipped with rubber spool for positive shut-off. Heavy duty handwheel control. Taper pins in vane are for positioning only; vane is keyed to shaft.

No. 579. Heavy Duty Float-operated Valve for control of liquid level. Supplied in any desired metal to resist corrosion by liquid controlled.

No. 602. 24-inch 150-pound Cast Steel Valve with Series 15 raised face flanges, air-cylinder positioner, handwheel and declutching unit. Constant 90° angularity between prime mover and valve stem. Controls liquids or gases.



They're Cutting the Cost On Cooling Tower Water

Here is another fine Layne installation for providing cooling tower water for one of the major petroleum industry companies. Here again is a move toward real water economy.

Layne makes these installations complete;—exploration, well drilling, pumps, pump setting, testing and delivery of the units in operation. There is no divided responsibility. No waiting for a second crew to finish up. No delay on delivery of pumping equipment.

All Layne Well Water Systems are equipped with the famous high efficiency Layne Vertical Turbine pumps—the finest that skillful engineering and factory craftsmanship can create. Construction throughout is now more rugged than ever before—longer lasting—and smoother in operation. For catalogs, bulletins, etc., address

LAYNE & BOWLER, INC.
General Offices
MEMPHIS 8, TENN.

Vertical Turbine PUMPS

Layne Vertical Turbine Pumps in the latest and most efficient design are now available in sizes from 40 to 16,000 gallons per minute, using electric motor, combustion engine or steam turbine drives. Their fine features are illustrated in Layne's Pump Catalog, sent promptly on request.

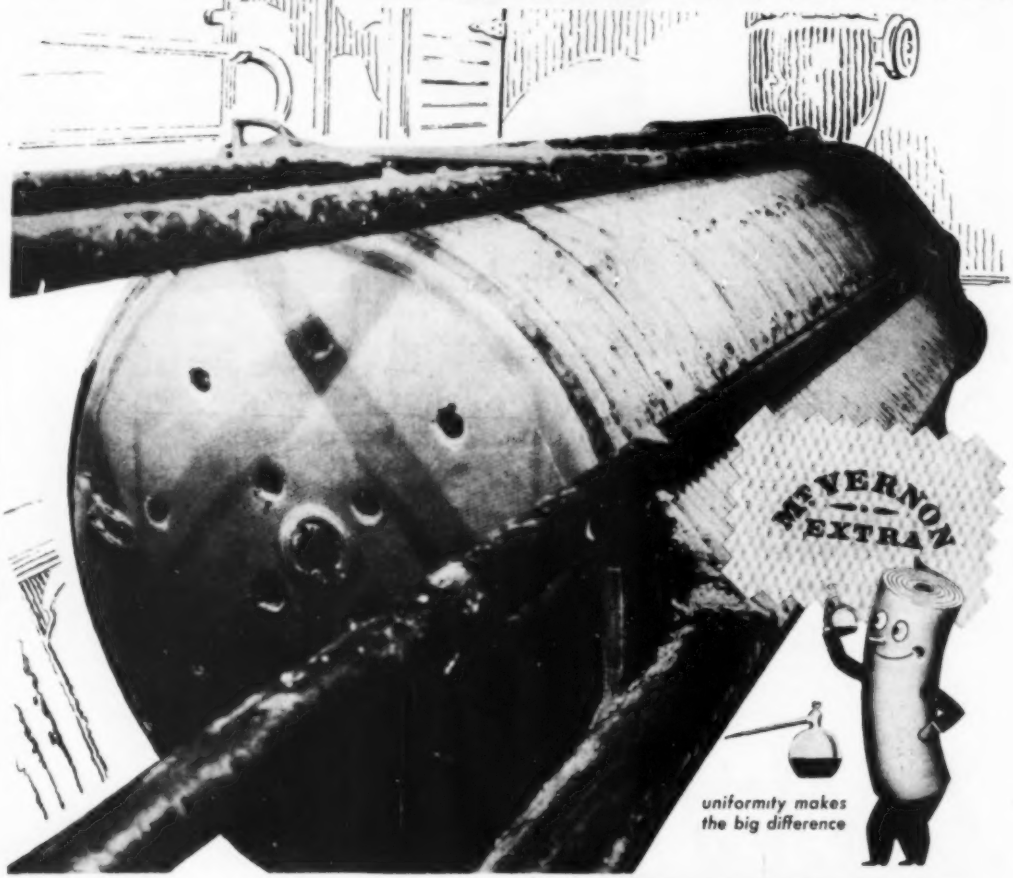
LAYNE

WELL WATER SYSTEMS

AFFILIATED COMPANIES—Layne-Arkansas Co., Stuttgart, Ark. ★ Layne-Atlantic Co., Norfolk, Va. ★ Layne-Central Co., Memphis, Tenn. ★ Layne-Northern Co., Mishawaka, Ind. ★ Layne-Louisiana Co., Lake Charles, La. ★ Louisiana Well Co., Monroe, La. ★ Layne-New York Co., New York City ★ Layne-Northwest Co., Milwaukee, Wis. ★ Layne-Ohio Co., Columbus, Ohio ★ Layne-Pacific, Inc., Seattle, Wash. ★ Layne-Texas Co., Houston, Texas ★ Layne-Western Co., Kansas City ★ Layne-Minnesota Co., Minneapolis, Minn. ★ International Water Corporation, Pittsburgh, Pa. ★ International Water Supply, Ltd., London, Ontario, Canada ★ Layne-Hispano Americana, S. A., Mexico, D. F.

Filtering Starts with the Fabric

Filtering efficiency depends to a great degree on fabric uniformity. That's why Mt. Vernon Extra is preferred by those who specify filter fabrics. They know that greater fabric uniformity means greater clarification of filtrates, more complete recovery of solids. They know, too, how the wear-resistant qualities of Mt. Vernon Extra cut their repair and replacement costs—how these fabrics stand up to the rough punishment of filter-fabric cleaning. It's all in the way Mt. Vernon Extra is made—from top grades of cotton under rigid laboratory controls. To insure a high degree of fabric uniformity specify Mt. Vernon Extra.



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For any refinery piping job . . .
Crane has everything you need

Take This Steam Utility Piping, for example. All valves, fittings, fabricated piping, pipe and accessories shown here typify the unequaled selection you get at Crane. Whether the fluids you are handling call for brass, iron, steel or corrosion-resistant alloys, most likely Crane has the equipment you need. And you get it all on one order to your nearest Crane Branch or Wholesaler.

Relying on this **One Source of Supply** is the way to make the most of any standardization program. For the Crane line is complete enough to simplify every piping procedure, from design to erection to maintenance. **One Responsibility** for materials—all designed to rigid refinery specifications—helps you get better installations, avoids needless delays. **High Quality** in each item from Crane helps to assure efficient, dependable performance throughout piping systems.

CRANE CO., 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

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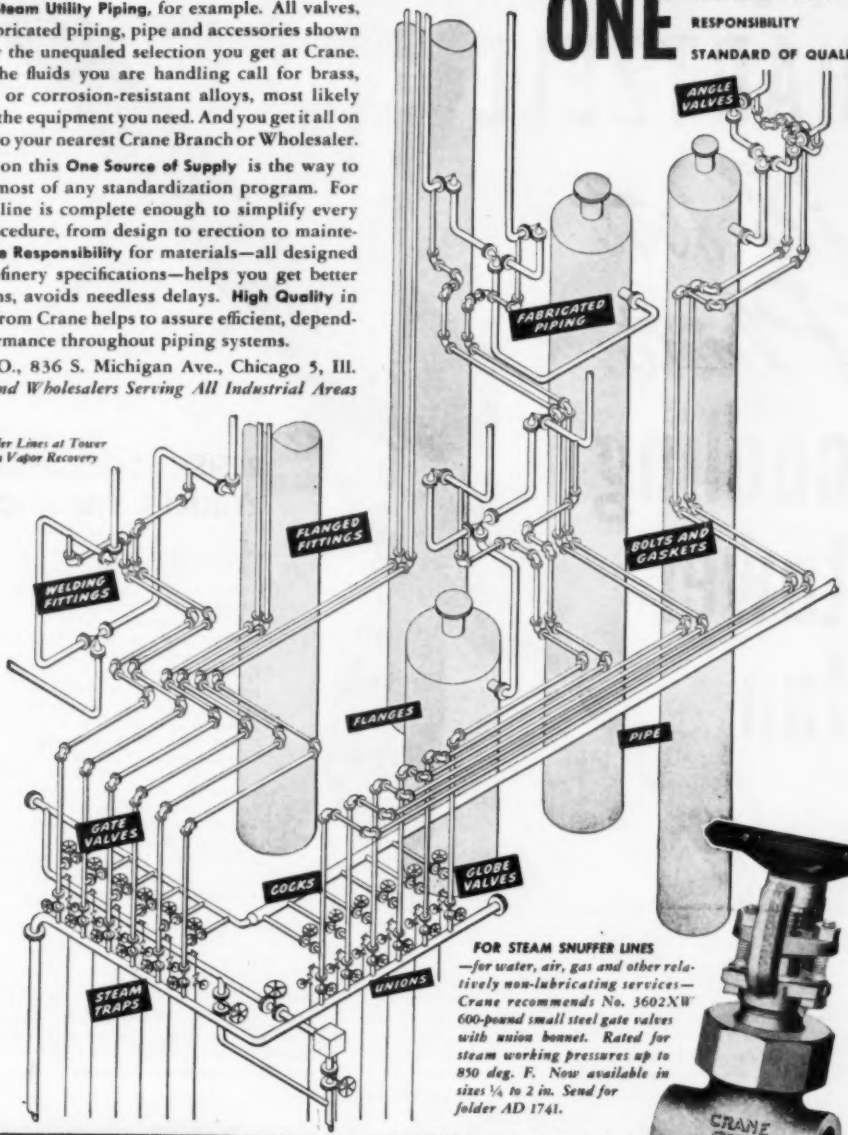
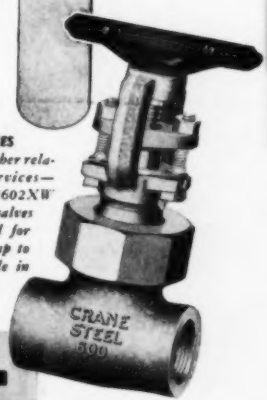


Steam Snuffer Lines at Tower Structure on Vapor Recovery Unit.

FOR STEAM SNUFFER LINES
—for water, air, gas and other relatively non-lubricating services—Crane recommends No. 3602XW 600-pound small steel gate valves with union bonnet. Rated for steam working pressures up to 850 deg. F. Now available in sizes ¼ to 2 in. Send for folder AD 1741.



EVERYTHING FROM . . .

VALVES • FITTINGS
PIPE • PLUMBING
AND HEATING

CRANE

FOR EVERY PIPING SYSTEM

the HARTZELL *18 foot Plastic* cooling tower fan

NOW

RESISTS CORROSION
REDUCES VIBRATION

In 1941 Hartzell introduced a material—Hartzite plastic—which provides amazing resistance to corrosion damage. It also dampens vibration and resists damage from it.

In 1941 Hartzite plastic was a new material. In 1949 it is one which has thoroughly proved itself in cooling tower fans of from 10 to 16 feet diameter. Where it has been tried it has been specified regularly on following fans for the same user.

Now an 18-foot fan, with Hartzite plastic blades, is available. It is in actual use on cooling towers *now*. Its Hartzite plastic blades are not "notch-conscious," which means that a crack resulting from contact with a foreign object will not enlarge under vibration. Hartzite plastic has been used for years in airplane propellers, operating at very high speeds, without failure. It absorbs less than 1% of water and is not affected by 250-degree heat or minus-40-degree cold. It is practically impervious to most acids, alkalies, salt water and weathering.

We build a full range of cooling-tower fan sizes, from 3 to 18 feet diameter. Blades of fans smaller than 10 feet are of cast aluminum alloy—ideal in that size range.

Hubs of all Hartzell cooling-tower fans possess strength many times greater than the minimum essential. Pitch of all blades can easily be changed to compensate for changes in air needs or in atmospheric conditions.

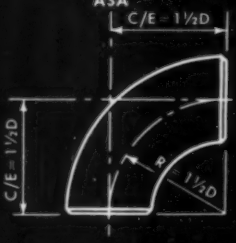
Send for our new Bulletin 1502, with complete cooling-tower fan data. And make sure that specifications for the cooling tower you buy or build call for a Hartzell fan or fans. There's no better insurance of top performance *and* long life.

HARTZELL PROPELLER FAN CO.
DIVISION OF CASTLE HILLS CORPORATION
PIQUA, OHIO

PROPELLER TYPE FANS AND BLOWERS • ROOF VENTILATORS • UNIT HEATERS • ENGINEERING OFFICES IN PRINCIPAL CITIES

Improvements and economies in welded piping result from this *Variety* of MIDWEST ELBOWS

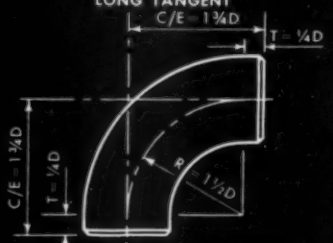
1
LONG RADIUS ASA



SIZES: ¾" TO 24", INCLUSIVE

Dimensions conform to applicable size range of American Standard for Butt-Welding Fittings, ASA B16.9. Radius and center-to-end dimension equal 1½ times nominal pipe size.

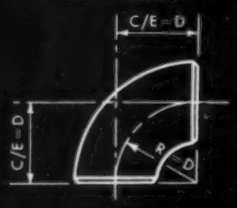
2
LONG RADIUS LONG TANGENT



SIZES: 2" TO 20", INCLUSIVE

Same radius as ASA Elbows but with long integral tangent on each end—an exclusive Midwest feature that saves time and pipe. No price increase over ASA Elbows.

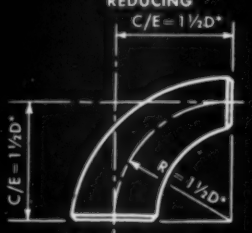
3
SHORT RADIUS



SIZES: 1" TO 30", INCLUSIVE

Where space limitations prevent use of ASA Elbows or Midwest "Long Tangent" Elbows shown above at right, these short turn elbows without tangents are recommended.

4
LONG RADIUS REDUCING



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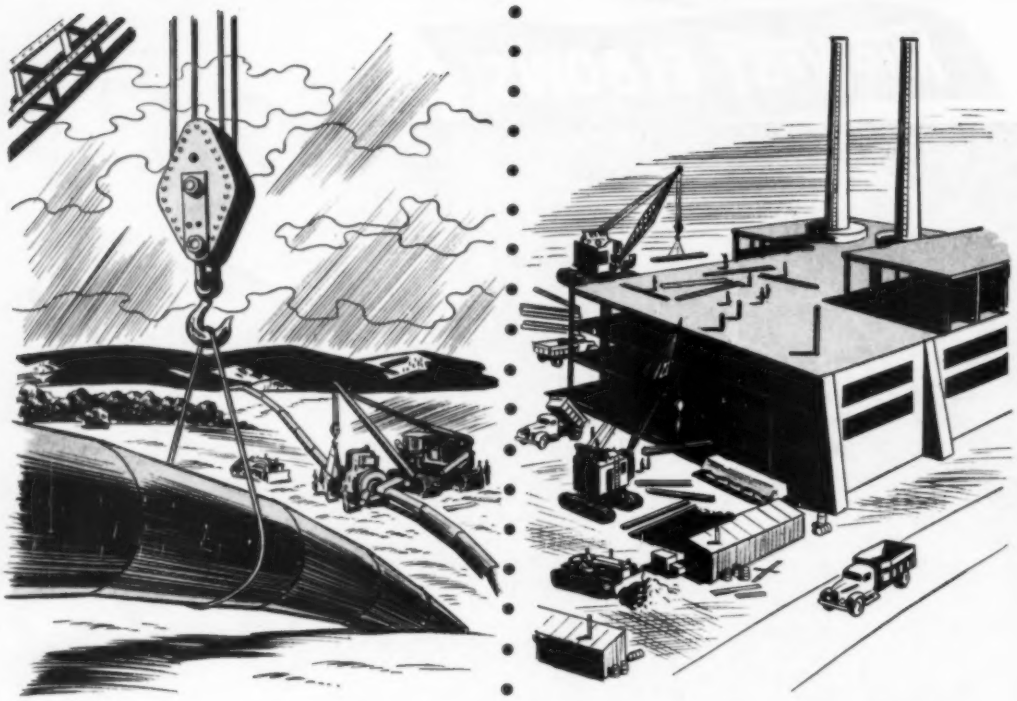

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PETROLEUM
REFINER

VOLUME 28, NO. 3 MARCH, 1949

The LOOK BOX

THE mushrooming use of petroleum as a chemical raw material has brought new problems to the chemical industry. Where it used to be that a given chemical was produced from only one raw material, say coal, a chemical company now has alternate sources or raw materials, coal and petroleum.

Petroleum To the Fore

Marcus Sittenfield, a consulting engineer of Philadelphia, discussed this situation during the last annual meeting of the American Institute of Chemical Engineers.

"Formerly agricultural products, coal, and petroleum each served as a relatively distinct source of raw materials for conversion into specific chemicals," he said. "Such products as toluene, vinyl resins, and others have been derived from coal. Agricultural products were the source of such chemicals as ethyl alcohol, glycerine, acetic acid, and others. Today these and many other products are being made from petroleum hydrocarbons.

"There are a number of factors which are responsible for the increasing use of petroleum products in producing organic chemicals. These are the reactivity of petroleum hydrocarbons, the apparently unlimited supply of petroleum hydrocarbons, the growing necessity for petroleum companies to utilize the by-products of refining operations to the fullest, the intensive research program that has been carried over the past years on the utilization of these materials, and the development of new and improved processes."

THE serious petroleum shortage problems of a year ago have been overcome. The current supply-demand situation within the industry is considered good by most authorities.

"American Competition"

L. J. Logan, economics editor of THE REFINER, gives detailed figures on the situation in his annual review, an article that commences on page 89 of this issue.

R. M. Bartlett, vice president of Gulf Oil Corporation, emphasized the same condition in a recent address when he declared the petroleum industry is re-entering a period of "typical American competition" with shortages overcome, production up and rapidly expanding markets in view.

Gasoline stocks on the East Coast, for instance, have been enlarged by 11 percent over a year ago and with a 6½ percent increase in total gasoline consumption forecast for this year as against 1948, we should go into the summer in good shape for an old-fashioned competitive battle, he declared.

Current estimates predict a rise in gasoline consumption in 1953 to about 22 percent more than last year, he said.

In the heavy fuel oil field, prices are down, stocks are up, and the industry is looking for new sales outlets. Bartlett's comment:

"The industry's program of modernization and improvement has succeeded so well that we are again able to compete with coal . . . The battle of the two giant energy sources, oil and coal, is on again in full force."

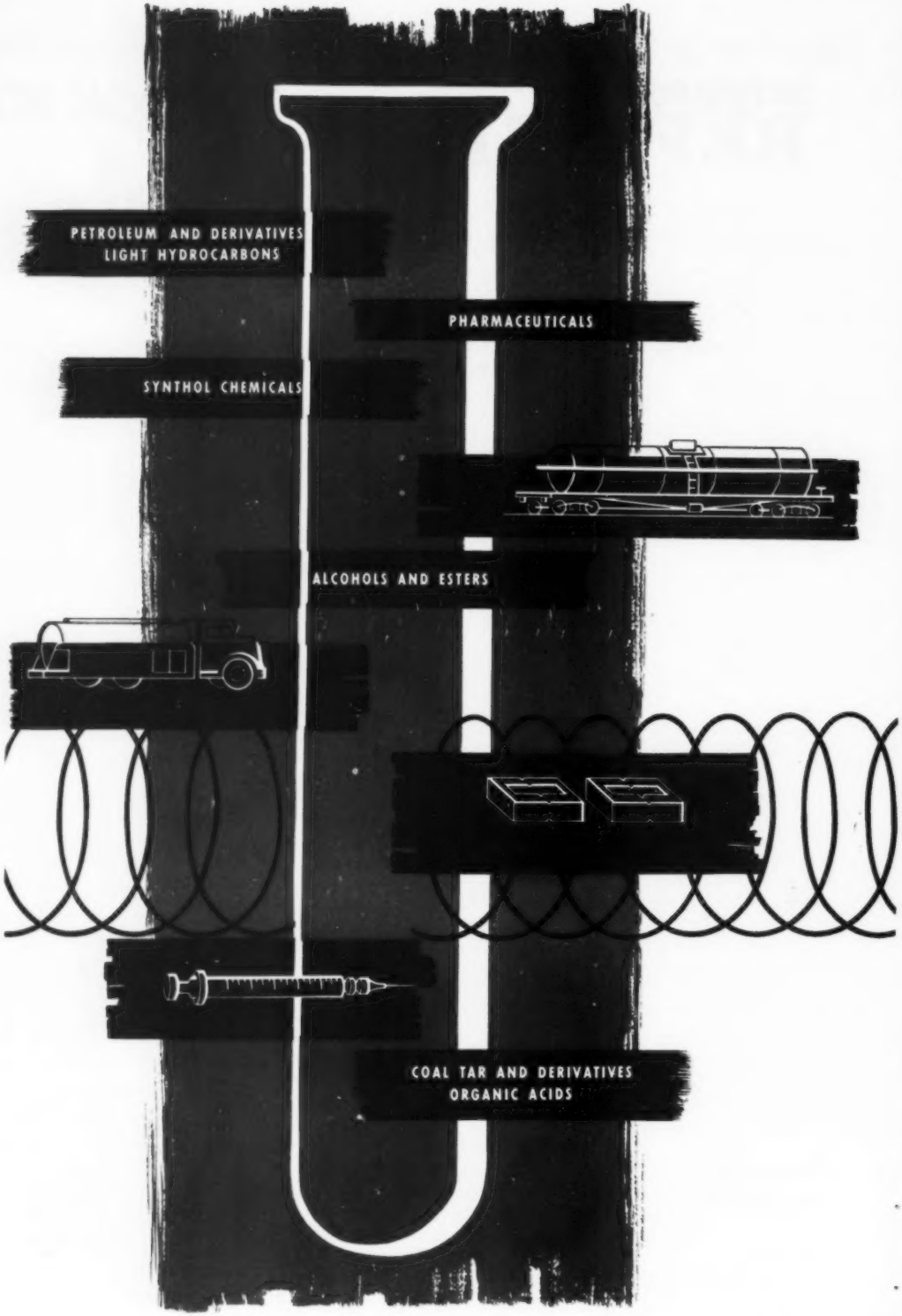
With reference to domestic heating oils, Bartlett cited that 45 percent of American families express preference for central oil heat, but only 20 percent to date have oil furnaces installed. He thought "there are another 5 million families who want the convenience of oil heating and are waiting to be convinced they should go ahead."

However, the Gulf man cautioned, this business will not be served up on a silver platter, but can be obtained only by aggressive, prewar type salesmanship.

Speaking of diesel fuel Bartlett pointed to the phenomenal growth in recent years of the diesel demand.

"Excluding sales to the armed forces, other sales have just about doubled in two years," he declared. "The greatest volume increase can be attributed to the switch by the railroad from steam to diesel equipment. For this use alone the total sales of diesel fuel jumped from 12 million barrels in 1945 to more than 20 million barrels in 1947. And it is estimated that the railroad use of diesel fuel soared to about 31 million barrels last year."

The petroleum industry has successfully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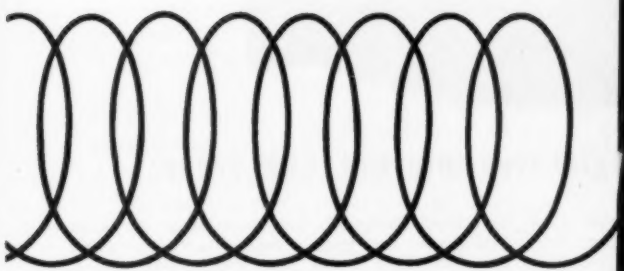

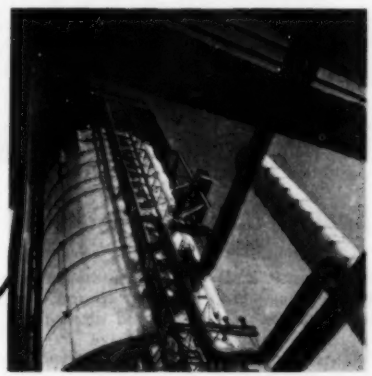

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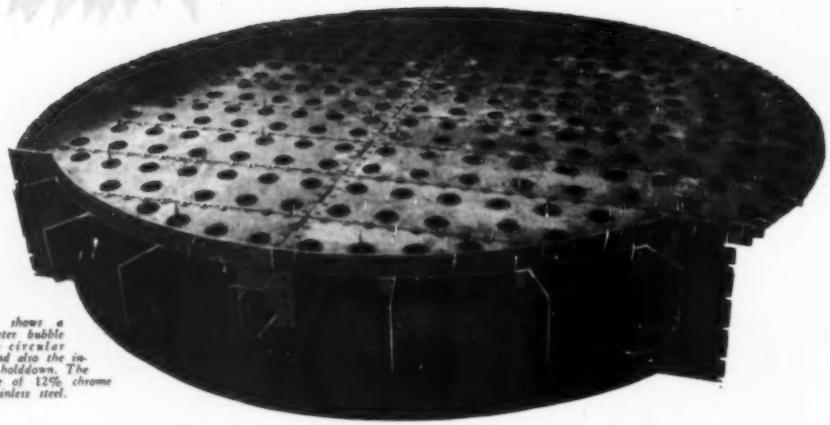

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equipped itself to meet these demands, he cited.

And "we can quickly gear ourselves to make available to the armed services the vast additional quantities of petroleum products which Secretary of Defense Forrestal estimated would be required in case of another war," Bartlett reminded.

Only by plowing back into production the lion's share of their earinngs in recent years, have the oil companies been able to achieve such unprecedented output, he emphasized.

For the same purpose, all companies have had to obtain from outside sources large sums through loans, sale of stock and of capital assets. In 1948 alone the industry's investment in necessary plant and equipment reached the staggering total of $2.5 billion.

This expenditure has been necessary because all signs point to steadily increasing oil consumption, Bartlett said. The population is increasing, more cars are being purchased in all income brackets, and the average mileage driven per car is rising.

Meanwhile, growth of petroleum use on the farm, in industry, and in the home continues—like the oil industry must—at a phenomenal rate.

Standard Technique

MAINTENANCE of the profit system in American business as a means of perpetuating the free enterprise system, assuring the success of both small and large business enterprises, and forestalling any necessity for government interference and control was urged last month by Harry J. Kennedy, vice president of Continental Oil Company.

"Earning statements of big industry make inviting targets for those who would first discredit profits and then destroy them," he said. "This is the standard collectivist technique for killing off new venture capital and private borrowing. If conditions can be so developed that the Reconstruction Finance Corporation must do all industry financing—and if it can all be distress financing because of business losses instead of profits—government will have taken over.

"To the enemies of the profit system of incentive in business, every profit is too big," continued the oil company official. "A rule that makes certain profits evil because the leftists can't take a slice of them, or because they are bigger than some one else's, plainly condems all profits.

"Under the free enterprise system, profits are earned—not obtained by demand. They are created—managed into existence by imagination, ingenuity, foresight, struggle, and sound decisions. In our American way they are not procured by frightening them out of someone else who assembled them. They are never easy to create and never guaranteed. In a free economy, profits are not something which can be capriciously dispensed on favoritism or whim or clamor. The idea of dividing or redistributing profits arbitrarily on claims of need is not a democratic idea."

Speaking of oil industry profits, Kennedy stated that such earnings must necessarily be high enough to justify expensive exploration projects to assure a future supply of petroleum products for America.

A number of oil companies are now engaged in exploration and drilling operations in the tidelands areas in the Gulf of Mexico off the coasts of Texas and Louisiana, and in the Pacific Ocean off the coast of California, he pointed out, continuing, "it has been estimated that the companies engaged in this work hope to find 10 to 15 billion barrels of oil—possibly more. Even at a recovery rate conservatively estimated at a half million barrels per well, it will take 30,000 wells to produce 15 billion barrels of oil. And it is also conservatively estimated that this program will cost a total of $6 billion.

"That's a figure for capital outlay that can't be managed by a pauper industry," Kennedy declared. "Other industries are faced with the same kind of problems. They must make profits to insure their future success—which means perpetuation of widespread employment and high living standards."

Gasoline Getting Better

GASOLINE quality continues to rise. Regular and premium grades during the summer of 1948 were of slightly higher quality with respect to octane ratings than those sold during the two preceding summers, reflecting a continued upward trend, according to the semi-annual survey of motor fuels recently released by the Bureau of Mines.

The report shows that the octane ratings of regular gasolines sold in the summer of 1948 averaged 75.2 compared with 75.1 for the summer of 1947 and with 74.4 during 1946. Similarly, the ratings of premium-priced gasolines last summer averaged 79.5 as compared with 79.2 during the previous summer and with 78.3 and 74.9 respectively, for the two preceding summers.

Including service station gasolines of 115 major and minor companies, the survey of last summer was the second made by the Bureau in cooperation with the American Petroleum Institute.

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Refinery Output Deemed Adequate As Year 1949 Commences

L. J. LOGAN
Economics Editor

DUE to an excessively high level attained by refinery operations in 1948, an entirely different set of conditions will confront United States petroleum refiners in 1949. In contrast with the past year, only a relatively small increase in crude runs to stills should be adequate to meet consumption rates this year. Furthermore, output of various refined products must be adjusted with care to market requirements if the creation of excessive stocks is to be avoided.

This complete change in the refining picture is a result of refiners out-doing themselves during the past year. Processing of far more crude oil than ever before by U. S. refineries resulted in the manufacture of so much refined products during 1948 that the supply shortage of the previous year was overcome completely. Besides satisfying increased consumer requirements, refinery output increased to such an extent that stocks of refined products soared to levels which make it desirable to avoid further additions to storage in 1949. Nevertheless, it is indicated that refiners must handle somewhat larger quantities in 1949 so as to provide sufficient supplies of products to meet anticipated growth in consumption.

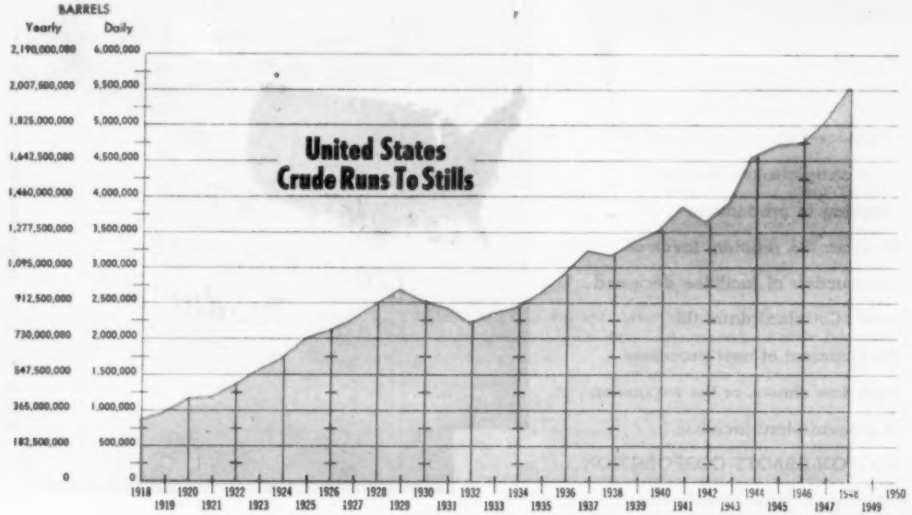
Large Increase Rate

Refinery operations last year rose by an unusually large amount, crude runs to stills being 9.4 percent or 476,000 barrels per day above 1947 levels. This constituted the second largest annual rate of increase in history. The only time a greater annual gain ever occurred was when expansion of war efforts sent 1944 refinery runs upward by 634,000 barrels daily from the preceding year.

A total of 2,031,649,000 barrels of crude oil was charged to refinery stills during the 12 months of 1948, which was 179 million more than in 1947 and 300 million barrels over the 1946 rate. This volume was twice the amount of crude refined as recently as 1935, which represented a new high peak at the time. The processing of this quantity of crude by refiners resulted in the establishment of a daily average crude run to stills of 5,551,000 barrels in 1948, contrasted with 5,075,000 barrels in 1947 and 4,470,000 barrels in 1946.

This high rate of refinery operations was more than enough to satisfy all consumer wants, and stocks of refined products increased an average of 215,000 barrels per day during 1948.

Prospective petroleum consumption indicates that refiners will be required to process more crude in 1949 than the peak attained last year. However, because of the accumulation of large refined product stocks the past year, refiners will be able to keep pace with consumption by a much smaller rate of increase over 1948. In contrast with the 9.4 percent increase in



(All Figures In Barrels)

YEAR	Annual Total	Daily Average	YEAR	Annual Total	Daily Average	YEAR	Annual Total	Daily Average	YEAR	Annual Total	Daily Average
1918	328,025,000	893,200	1926	779,264,000	2,135,000	1934	895,636,000	2,453,800	1942	1,334,103,000	3,655,000
1919	361,520,000	990,500	1927	828,835,000	2,270,800	1935	965,790,000	2,646,000	1943	1,429,738,000	3,917,000
1920	433,915,000	1,185,600	1928	913,295,000	2,495,300	1936	1,068,570,000	2,919,000	1944	1,665,684,000	4,551,000
1921	443,363,000	1,214,700	1929	987,708,000	2,706,100	1937	1,183,440,000	3,242,000	1945	1,719,534,000	4,711,000
1922	500,706,000	1,371,800	1930	927,447,000	2,541,000	1938	1,165,015,000	3,191,800	1946	1,730,197,000	4,740,000
1923	581,238,000	1,592,400	1931	894,608,000	2,451,000	1939	1,237,840,000	3,391,000	1947	1,852,246,000	5,074,000
1924	643,719,000	1,758,800	1932	819,997,000	2,240,400	1940	1,294,283,000	3,536,300	1948	2,031,649,000	5,551,000
1925	739,920,000	2,027,200	1933	851,384,000	2,359,600	1941	1,409,192,000	3,860,800	1949 Est.	2,113,350,000	5,790,000

Source:—U. S. Bureau of Mines, except for latest year which has been calculated from Bureau statistics for first 10 months and American Petroleum Institute weekly reports for the last two months.

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quantity of crude refined in 1948, it appears that a gain of 4.3 percent in volume of crude charged to stills will be adequate. Consequently, crude runs to stills in 1949 are expected to average 5,790,000 barrels daily, which will be 239,000 barrels per day more than the 1948 daily average but only about half the rate of gain which took place between 1948 and 1947 refining levels.

If 1949 crude runs do not exceed 5,790,000 barrels per day, a gain of 4.3 percent over 1948, a consumption increase of 7.5 percent can still be met and further additions to refined product stocks can be prevented. At this level, daily average crude runs in 1949 would be only slightly greater than the peak of 5,743,000 barrels charged to stills in December, 1948.

Facilities Are Added

Completion of new refining facilities made possible the processing of a record amount of crude oil in 1948. U. S. refining capacity had increased to 6,076,000 barrels daily by the end of 1948, compared with 5,671,000 barrels at the close of 1947. Even with this gain in capacity, so much crude was processed last year it was necessary that refineries be operated at above normal levels. In December, 1948, they were operated 94.5 percent of their capacity, compared with a normal prewar utilization of approximately 85 percent.

An additional increase in refining capacity will occur during 1949. Refining capacity of the country may reach 6½ million barrels daily by next December as new units go on stream. This growth in refining capacity should make it possible for refiners to utilize less of their full capacity during 1949.

Division of Products

In processing 9 percent more crude in 1948 than in 1947, refiners made 9 percent more gasoline, 10 percent more kerosine, 21 percent more distillate fuel oil and 4 percent more residual fuel oil.

Refinery Production of Major Products and Percent Yield from Crude Run at U. S. Refineries

Results in December and Year, 1948, compared with same periods in 1947 and 1941. Figures are from Bureau of Mines except that November and December, 1948, are estimated with aid of A.P.I. weekly bulletins.

(THOUSANDS OF BARRELS)

ITEM	1941	1947	1948	% Diff. '41-'48	% Diff. '47-'48
*Gasoline:					
Production, December	61,640	72,764	81,046	+ 31.5	+ 11.4
(Daily Average)	1,988	2,347	2,614	+ 31.5	+ 11.4
Percent Yield from Crude	45.7	40.4	41.9	.....	.....
Production, Whole Year	671,110	814,841	894,498	+ 33.3	+ 9.8
(Daily Average)	1,839	2,232	2,444	+ 32.8	+ 9.5
Kerosine:					
Production, December	6,682	10,129	11,173	+ 67.2	+ 10.3
(Daily Average)	215	327	360	+ 67.2	+ 10.3
Percent Yield from Crude	5.3	6.1	6.3	.....	.....
Production, Whole Year	72,586	110,412	122,234	+ 68.4	+ 10.7
(Daily Average)	199	302	334	+ 67.8	+ 10.6
Distillate Fuel Oil:					
Production, December	17,142	30,759	34,051	+ 98.6	+ 10.7
(Daily Average)	553	992	1,098	+ 98.6	+ 10.7
Percent Yield from Crude	13.7	18.5	19.1	.....	.....
Production, Whole Year	189,177	312,173	380,167	+101.0	+ 21.8
(Daily Average)	518	855	1,039	+100.6	+ 21.5
Residual Fuel Oil:					
Production, December	31,127	39,746	40,132	+ 29.0	+ 1.0
(Daily Average)	1,004	1,282	1,295	+ 29.0	+ 1.0
Percent Yield from Crude	24.9	23.9	22.5	.....	.....
Production, Whole Year	342,367	447,795	466,807	+ 36.3	+ 4.2
(Daily Average)	938	1,227	1,275	+ 36.0	+ 3.9
Lubricants:					
Production, December	3,554	4,566	4,626	+ 30.2	+ 1.0
(Daily Average)	115	147	149	+ 30.2	+ 1.4
Percent Yield from Crude	2.8	2.8	2.6	.....	.....
Production, Whole Year	39,539	51,765	51,928	+ 31.3	+ 0.3
(Daily Average)	108	142	142	+ 31.5	.....

* Production includes straight run, cracked and natural blended at refineries. Yield indicates percent of crude runs made into straight run and cracked gasoline.

Says Proposed Tax Threatens Texas Refining

Replacement of the present four cents per gallon state retail gasoline tax with a proposed one cent per gallon processing tax on gasoline and other combustible fuels will make it impossible for the Texas refining industry to compete with other states, Andrew M. Howsley, general counsel for the Texas Mid-Continent Oil and Gas Association, told members of the Permian Basin chapter of the American Petroleum Institute recently.

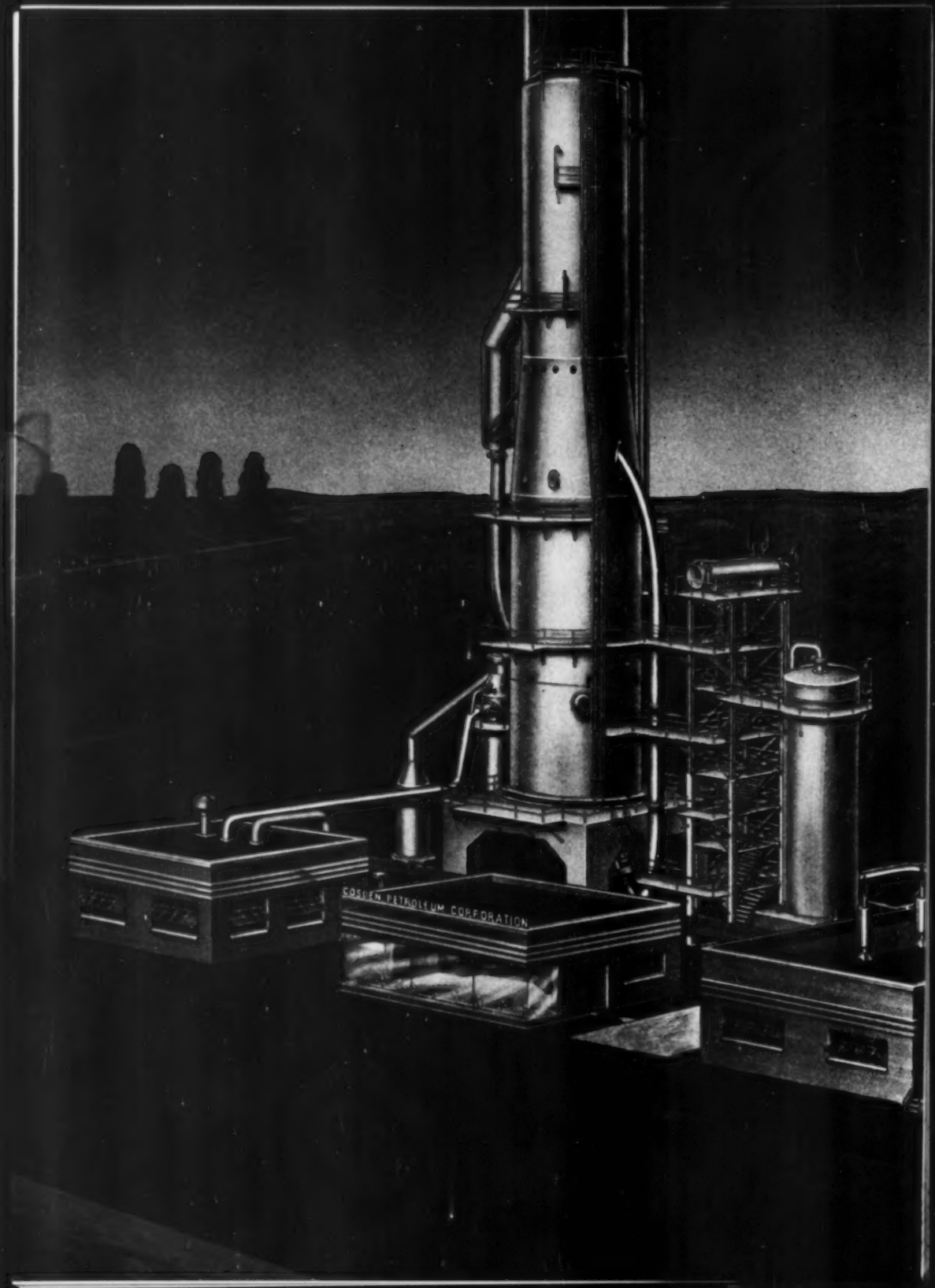
The tax, estimated at $145 million, would have to be made up in Texas operations, if the refineries continue to sell their product in a competitive market, Howsley stressed. Operational cost cuts could account for only a fraction of the tax, he explained.

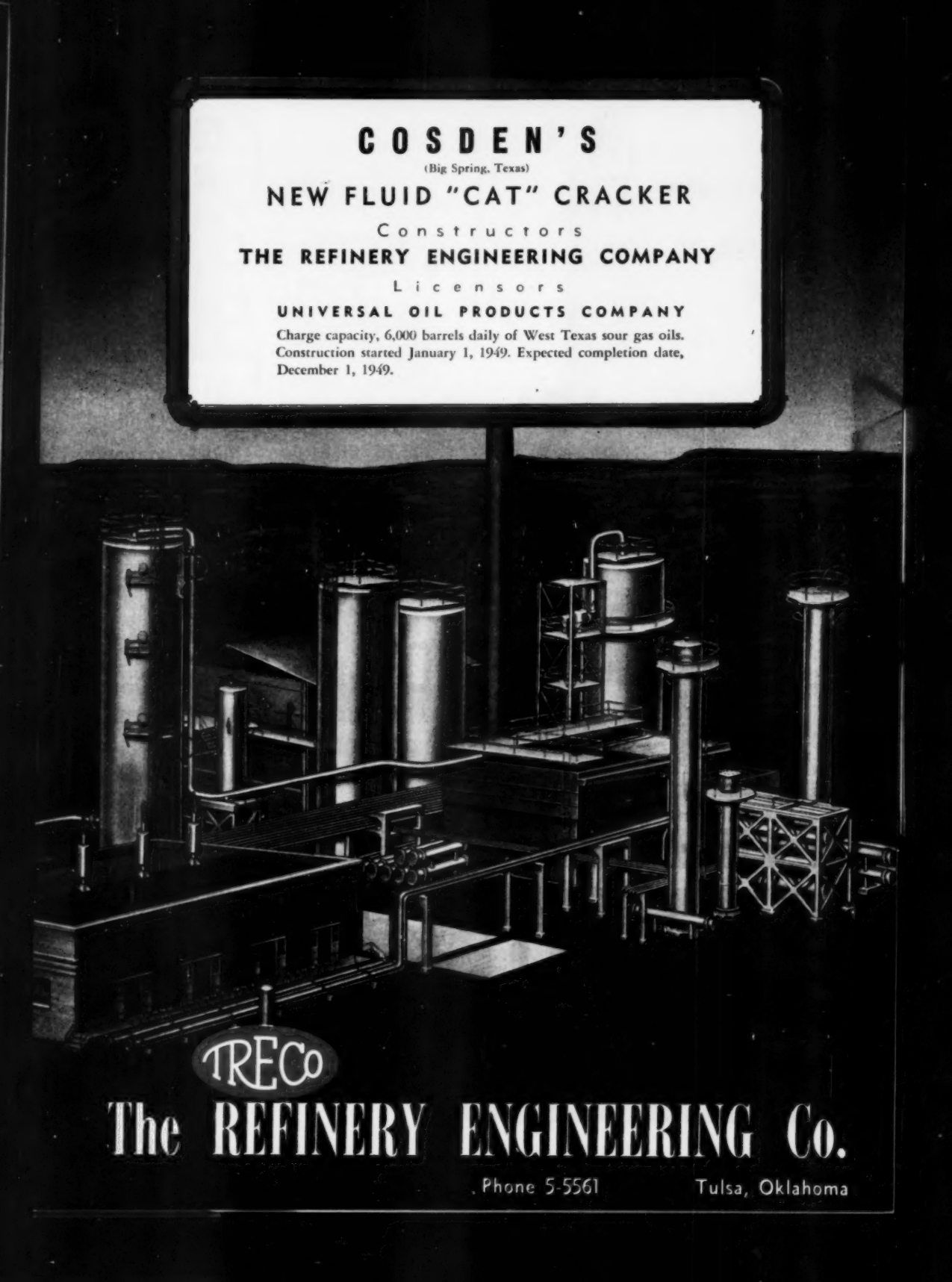
With the present production tax about 11 cents per barrel and the proposed tax amounting to approximately 19 cents per barrel of crude, this would mean a total of 30 cents per barrel tax on the crude producer if the tax were passed back to him, Howsley predicted. For this reason, the tax would cause a movement of the refining industry into other states, he concluded.

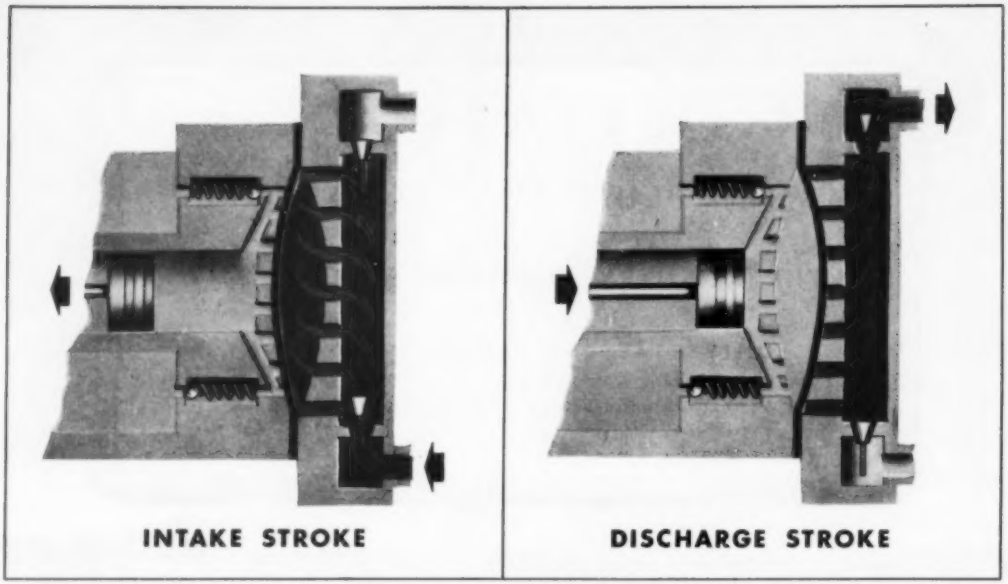
Crude Runs to Stills in U. S. Refineries and Percent of Refinery Capacity Used by Districts, December and Years, 1941, 1947 and 1948. Runs from Bureau of Mines, except November and December, 1948, from American Petroleum Institute; Capacities from American Petroleum Institute.

(THOUSANDS OF BARRELS)

Refining District	CRUDE RUN IN DECEMBER: Total Amount Run During Month				CRUDE RUN IN DECEMBER: Daily Average Run During Month			REFINING CAPACITY AND USE IN DECEMBER: Daily Capacity			REFINING CAPACITY AND USE IN DECEMBER: Percent Capacity Used			CRUDE RUN DURING YEAR: Total Amount Run During Year			CRUDE RUN DURING YEAR: Daily Average Run During Year			
	Dec., 1941	Dec., 1947	Dec., 1948	% Diff. '47-'48	Dec., 1941	Dec., 1947	Dec., 1948	Dec., 1941	Dec., 1947	Dec., 1948	Dec., 1941	Dec., 1947	Dec., 1948	1941	1947	1948	1941	1947	1948	% Diff. '47-'48
East Coast	19,750	25,950	26,571	+ 2.4	637	837	857	704	819	854	90.5	102.2	100.4	217,046	297,315	317,411	595	815	867	+ 6.4
Appalachian	4,575	5,127	5,458	+ 6.5	148	166	176	174	188	193	85.1	88.3	91.2	53,499	60,377	57,471	147	165	157	— 4.8
District No. 1	.....	2,902	3,250	+ 12.0	.....	94	105	.....	123	125	.....	76.4	84.0	.....	35,793	36,227	.....	98	99	+ 1.0
District No. 2	.....	2,225	2,208	— 0.8	.....	72	71	.....	65	68	.....	110.8	104.4	.....	24,584	21,244	.....	67	58	— 13.4
Ind., Ill., Ky	22,078	26,724	29,179	+ 9.2	712	862	941	776	949	1,015	91.8	90.8	92.7	251,257	301,357	332,065	688	826	907	+ 9.8
Okla., Kans., Mo.	10,711	13,144	13,433	+ 2.2	346	424	433	418	454	497	83.3	93.4	87.1	127,130	153,050	165,000	348	419	451	+ 7.6
Inland Texas	5,761	7,978	7,799	— 2.2	186	257	252	265	290	296	70.2	88.6	85.1	66,640	84,582	89,898	183	232	246	+ 6.0
Texas Gulf Coast	33,919	41,347	45,336	+ 9.6	1,094	1,334	1,463	1,117	1,310	1,446	97.9	101.8	101.2	363,252	437,024	510,131	995	1,198	1,394	+ 16.4
Louisiana Gulf Coast	4,925	12,429	14,338	+ 15.4	159	401	463	172	352	401	92.4	113.9	115.5	54,300	139,940	159,230	149	383	435	+ 13.6
Ark., and La. Inland	2,613	2,417	2,692	+ 11.4	84	78	87	97	113	99	86.6	69.0	87.9	29,365	24,525	29,810	80	68	81	+ 19.1
Rocky Mountain	2,848	4,740	5,097	+ 7.5	92	152	164	137	183	194	67.2	83.1	84.5	33,570	52,343	59,420	92	143	163	+ 14.0
District No. 3	.....	352	447	+ 27.0	.....	11	14	.....	13	15	.....	84.6	93.3	.....	3,785	4,600	.....	10	13	+ 30.0
District No. 4	.....	4,388	4,650	+ 6.0	.....	141	150	.....	170	179	.....	82.9	83.8	.....	48,558	54,751	.....	133	150	+ 12.8
California	17,805	26,003	28,120	+ 8.1	574	839	907	787	1,013	1,081	72.9	82.9	83.9	213,133	301,433	311,213	584	826	850	+ 2.9
Total United States	124,985	165,858	178,023	+ 7.3	4,032	5,350	5,743	4,647	5,671	6,076	86.8	94.3	94.5	1,409,192	1,862,246	2,031,649	3,861	5,075	5,551	+ 9.4


COSDEN PETROLEUM CORPORATION


COSDEN'S
(Big Spring, Texas)
NEW FLUID "CAT" CRACKER
Constructors
THE REFINERY ENGINEERING COMPANY
Licensors
UNIVERSAL OIL PRODUCTS COMPANY
Charge capacity, 6,000 barrels daily of West Texas sour gas oils. Construction started January 1, 1949. Expected completion date, December 1, 1949.
TRECo
The REFINERY ENGINEERING Co.
Phone 5-5561
Tulsa, Oklahoma



The schematic drawings above demonstrate the operating principle of the Lapp Pulsafeeder, and how it prevents contamination in proportioned pumping. The micro-adjustable reciprocating piston assures positive and accurately-measured displacement. But it pumps only oil or other neutral medium, which in turn actuates the diaphragm. This pulsating hydraulically-balanced diaphragm moves the chemical or liquid being handled, and isolates it from all pump parts. (In the drawing, diaphragm travel and other details are greatly exaggerated. In construction, diaphragm deflection is confined within the fatigue limit of the diaphragm material. A stainless steel diaphragm, 8½" diameter, on a pump designed to handle 80 gallons per hour, for example, has a maximum deflection of .080".)

HOW TO AVOID CONTAMINATION IN PROPORTIONED PUMPING

Lapp PULSAFEEDER

NO STUFFING BOX, no mechanical or liquid seal, absolutely no packing or other "leak-likely" gland can be in contact with liquid being handled.

CHEMICAL ISOLATED by diaphragm from working parts of pump.

HYDRAULICALLY-BALANCED DIAPHRAGM carries no load, isolates chemical being pumped from pump parts, without stresses on diaphragm itself.

MICRO-ADJUSTABLE to any rate of flow by calibrated handwheel, *while pump is in operation.*

PERFECT LUBRICATION assured—all moving parts submerged in oil bath.

CAPACITY ranges from less than 100 ml. per hour to 660 gallons per hour; pressures up to 2250 psig. Single head and duplex models in four sizes.

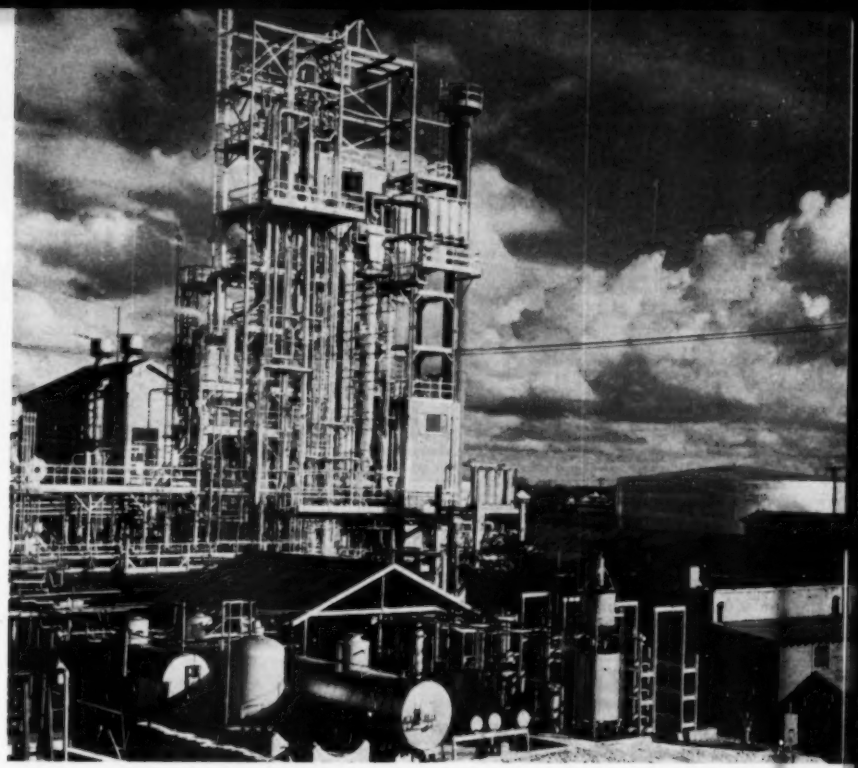
SEND FOR BULLETIN No. 262 which carries complete description and specifications.

Lapp Insulator Co., Inc., Process Equipment Division, 164 Maple St., Le Roy, N. Y.

Lapp PROCESS EQUIPMENT

CHEMICAL PORCELAIN VALVES • PIPE • RASCHIG RINGS

PULSAFEEDER CHEMICAL PROPORTIONING PUMPS



Hydrocarbon Synthesis Pilot Plant, Baton Rouge, Louisiana, Esso Standard Oil Company.

A Look at the Synthetic Fuels Picture

E. V. MURPHREE
President, Standard Oil Development Company, New York

FROM a straight economic standpoint, production of synthetic fuels from natural gas is competitive today with production of similar products from crude oil and with further process improvements, etc., production of liquid fuels from coal and oil shale may well become quite attractive from a cost standpoint. (The "etc.," above, it might be explained, includes further increases in the cost of finding and producing crude oil.)

These are the views of E. V. Murphree, president of Standard Oil Development Company, who sets forth "The Synthetic Fuels Picture" in the accompanying article, a slightly condensed version of the article, which under the same title, appeared in the February issue of WORLD OIL.

CONSUMPTION of oil products in the U. S. for 1947 was at the all-time high of 5,450,000 barrels per day, or about 2 billion barrels per year. This consumption was about 11 percent above the peak war year of 1945, and about 35 percent higher than the prewar year of 1941.

Presently, the oil reserves of the U. S. are estimated at slightly less than 25 billion barrels. The proven oil reserves of the U. S., however, have increased steadily through the years. During 1947, when consumption was its highest, the proven reserves were higher at the end of the year than at the beginning. Also there are very extensive known deposits of crude oil outside the U. S., particularly in Northern South America and in the Middle East.

About 35 billion barrels of oil have been produced in the U. S. This figure added to the 24 billion barrels of known reserves totals 60 billion barrels. Geologists estimate on a conservative basis that about 60 billion more barrels of oil will be found.

In view of increased demands, it seems unlikely that the U. S. can produce enough crude oil to meet demands. Most probably, a part of the future supply will be imported oil or else from a synthetic fuels industry, or both.

Due to the higher finding and producing costs for crude oil, synthetic fuel is becoming closer to broad economic application. For example, synthetic fuels from natural gas appear competitive with similar products from crude today. This is one incentive for the gradual establishment of a synthetic fuel industry. The second incentive comes from national security reasons.

Natural Gas Reserves

Natural gas is one of the most interesting materials for production of synthetic fuels, although it is limited in availability. Known natural gas reserves of the U. S. have been estimated at about 166 trillion cubic feet. Converted to oil it would be the equivalent of about 16 billion barrels, about 70 percent of the known oil reserves. Assuming the consumption of natural gas in the future to be about 6.1 trillion cubic feet per year, against 2.7 trillion at present, and the rate of discoveries and extensions at 10 trillion cubic feet per year, 3.9 trillion cubic feet would be available for synthesis alone to yield roughly 900,000 barrels per day of oil products, mainly gasoline. Allowing for increased industrial and heating use, it is believed

TABLE 1

Table of Approximate Estimates on Production of Fuels

Raw Material	Crude Oil	Natural Gas	Coal (In East)	Oil Shale
Investments				
a. For max. gasoline yield $/B/D gasoline	6500	8200	8500	8400
b. Possible housing investment $/B/D gasoline (for max. gasoline yield)	....	....	2900	900
Steel Requirements				
For max. gasoline yield Tons/B/D gasoline	7.8	7.9	5.2	7.4
Percent Gasoline in total liquid products max. gasoline case	87	90	89	87
Raw material price assumed or estimated	$2.78/B*	10¢/MCF*	$3.20/ton	$1.00/ton
Gasoline costs for max. gasoline yield—¢/gallon				
Raw material	8.8*	2.9*	3.9	4.2
Manufacturing less credits	4.3	8.9	12.7	11.8
Product transportation	1.0	1.0	....	....
Total	14.1*	12.8*	16.6	16.0
Added cost for housing if required	....	....	1.9	0.6
Effect of increase in raw material cost	$1/B adds 3.2¢/gal.	10¢/MCF adds 2.9¢/gal.	$1/ton adds 1.2¢/gal.	$1/ton adds 4.2¢/gal.
Effect of 10 percent return on investment in				
Manufacturing or	1.6¢/gal.	3.7¢/gal.	....	....
Manufacturing plus mining	....	....	5.6¢/gal.	5.5¢/gal.

* These figures are based on crude oil and natural gas prices and not on costs.

enough gas will be available to produce at least some 300,000 barrels per day of oil products.

Coal Reserves

U. S. reserves of coal, including lignite, amounts to almost 3 trillion tons. Present coal consumption is about 610 million tons annually. It is believed that there are enough indicated coal reserves to supply the country's needs both for coal as such and in addition coal for making all of our oil requirements, assuming ½ ton per barrel, for the next 1000 years or more. Considerable revision of this figure will undoubtedly be required.

Shale Deposit

Shale deposits in the U. S. are quite large. Deposits in Colorado alone represent an oil reserve of at least 10 billion barrels. There are also substantial deposits of tar sands which might be processed similarly to oil shales.

Fischer-Tropsch Process

Through work in the U. S. the Fischer-Tropsch process has been radically modified from the standpoint of engineering, process details, and catalyst. This process, as improved for U. S. conditions, has been well worked out on an experimental and pilot plant scale, and one commercial plant of about 7000 barrels per day capacity is being erected, while plans for another of similar size were discontinued because of high costs of all construction.

One method of converting coal into oil products is very similar to the method used for natural gas. This is a two-step process, as in the gas process, involving synthesis gas preparation and then its reaction over a catalyst. The second step for all practical purposes is identical for both raw materials, so that the development of the natural gas process has at the same time developed the second step of a process for conversion of coal to oil. Due to the difference in raw materials, the preparation of the synthesis gas from coal is quite different from that required for natural gas. It is believed that still further improvements can be made in the continuous production of synthesis gas from coal and considerable work along this line is now being carried out in this country.

An alternate method of producing oil products from coal is by hydrogenation. This process was extensively exploited in Germany and there is a large commercial plant in England. It is not believed, however, that production of oil from coal by the hydrogenation process will be as attractive as the use of the modified Fischer-Tropsch process.

The most important new developments in production of synthetic fuels come from a new method of handling ground solids, catalysts or raw materials, such as coal or oil shale. This new method is known as the "Fluidized Solids Technique" and was first developed by Standard Oil Development Company for catalytic cracking of oil.

The oil industry has been most active in research on synthetic fuels. About 20 years ago the Standard Oil Company (New Jersey) group started a research and development program on hydrogenation of oil and coal. Also, large oil hydrogenation plants were erected and operated for a number of years. At the end of the war work on the Fischer-Tropsch process for natural gas and oil, which stopped during the war, was picked up again.

In addition considerable work has been carried out on retorting of oil shale. A large scale demonstration of the process the Jersey group has developed for retorting oil shale will be made this year in cooperation with the Bureau of Mines. Other oil companies have also done a great deal of work on synthetic fuels.

Table 1 gives approximate estimates of the investments required per unit of capacity for producing gasoline from crude oil, natural gas, coal (based on Fischer-Tropsch process) and oil shale. The estimates for oil from coal assume the successful conclusion of development work now in progress on coal gasification. Estimated steel requirements and gasoline costs when processing for maximum gasoline are shown. The gasoline costs in the cases of crude oil and natural gas include 15 percent for capital charges based on the manufacturing investment and on that part of the transportation investment peculiar to the plant. The gasoline costs in the cases of oil shale and coal include 15 percent for capital charges based on both the mining and manufacturing investments, as well as on transportation investment peculiar to the plant. Other transportation costs are based on normal charges. The price for crude oil used is the present in the U. S. Gulf with transportation charges to the refinery, and natural gas has been taken at 10 cents per thousand cubic feet in the field. The figures on mining of oil shale are based on information from the Bureau of Mines and those for coal on information from Pittsburgh Consolidation Coal Company. The investments and steel for crude oil production are for the U. S.

Investments and costs in the table are for a considerably higher octane number gasoline than present premium grade gasoline. The gasoline octane number level used for the estimates will about satisfy a 10-to-1 compression ratio engine which is capable of giving about 30 percent more miles per gallon than present-day engines.

It will be noted that the production of gasoline from natural gas based on the price used for natural gas of 10 cents per thousand cubic feet compares quite favorably with production of gasoline from crude oil. This price may be at too low a level for the future. The estimated cost of producing gasoline from coal and oil shale is somewhat higher.

The figures on oil from coal in the accompanying table are for a location in the East and housing on the scale indicated may possibly not be required depending on the location. West of the Mississippi the coal available is normally of lower heating value and hence more is required per unit of gasoline produced.

Immediate Supply Not in Mind

It should be emphasized that synthetic fuel plants are not needed for, and can have little effect on, the immediate supply situation for oil products.

Assuming the U. S. can rely on Western Hemisphere crude oil production in times of national emergency, it is not at present clear whether synthetic fuel plants will be essential to help supply U. S. requirements in the future. From a straight economic standpoint, production of liquid fuels from natural gas is competitive today with production of similar products from crude oil. With further improvements in manufacturing technique and possibly in mining or with further increases in the cost of finding and producing crude oil, production of liquid fuels from coal and oil shale may well become quite attractive from a cost standpoint. Substantial progress is bound to result from the large amount of research and development now being carried out.

Oil Progress Week Is Designated for 1949

October 16-22, 1949, has been set aside by the Oil Industry Information Committee as "Oil Progress Week." Theme of this special industry-wide effort to tell the oil story to the public will be "Ninety Years of Progress," it being 90 years ago that the Drake well was drilled. The theme will also be used during the year in the advertising material of the oil committee.

Last year the industry had an "Oil Progress Day" on October 14. It has been expanded to a week in order to afford oil men a longer period to hold their meetings, make speeches and let the public meet the industry.

AN "EYE-OPENER" IN
Advanced Engineering

EVERY KNOWN REQUIREMENT of leading industries, every proved scientific advance in pneumatic control, every advantage of unmatched research and experience has guided the design of this truly modern controller. The results are simpler and more rugged construction, easier and permanently stable adjustments, unequalled performance.

Some M-40 parts such as the ball-pivot link and reset resistance are basically new. The entire mechanism presents a new criterion of simplicity and strength. Parts are made to machine tool precision and permanently aligned. Everything about the M-40 reflects advanced engineering, from its smoothly contoured front surface to its foolproof unit construction.

Such advanced engineering assures a long and profitable service life . . . another reason why more than 15,000 Model 40 Controllers have been purchased in the past 2 years.

FOXBORO
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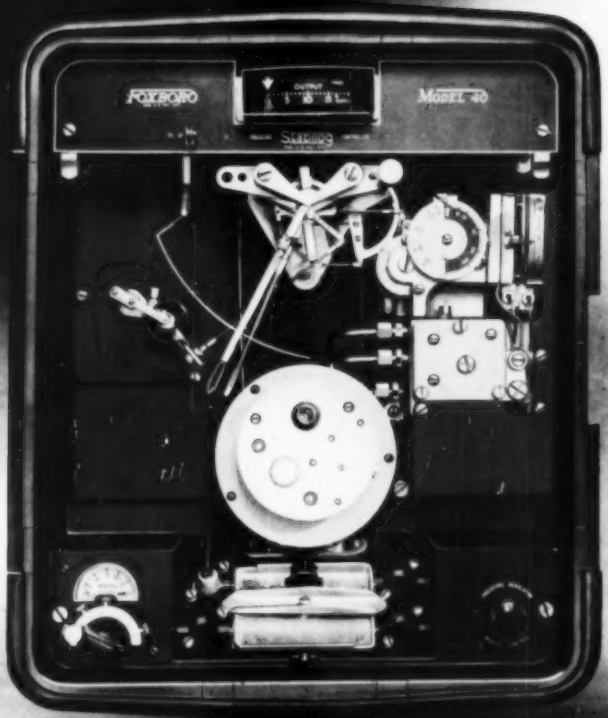
M-40

"THE FINEST MODERN CONTROLLER"

AN "EYE-OPENER" IN RESET ACTION

Radically New Conception of

WIDE RANGE RESET RESISTANCE



Wide-range, stepless, variable reset resistance is obtained without the use of needle valves or lengths of capillary tubing. No possibility of plugging . . . no critical setting to obtain precision adjustments. Movement of the setting lever changes flexure of a simple Bourdon Tube, varying its cross sectional area through a range of 500 to 1, permitting correct reset adjustment for any process. The reset scale, graduated in time-constant units, is logarithmic . . . therefore retains uniform sensitivity of setting over its entire range.

Hyper-Reset derivative action makes use of matched resistances placed side by side and calibrated so that optimum process control is obtained when both adjusting levers have the same setting. Both adjustments are reduced to a single operation!

The Model 40 Pneumatic Controller is available for temperature, pressure, flow, liquid level, humidity, density, etc., in a full range of control actions and combinations. Write for Bulletin 381. **The Foxboro Company, 262 Neponset Avenue, Foxboro, Mass., U. S. A.**

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M-40

"THE FINEST MODERN CONTROLLER"

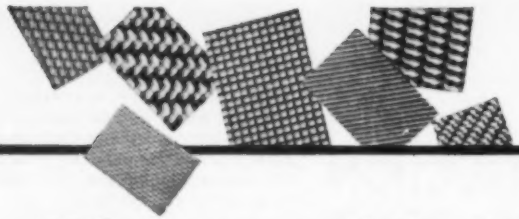
REFINERY and Other PLANT CONSTRUCTION

Petroleum Refiner's exclusive feature which, in boxscore form, presents a quick picture of the tremendous amount of plant construction work that is in progress or projected by oil and other companies in all sections of the world.

The tabulation presented each month under the heading "Refinery and Other Plant Construction" represents a continuing check of the building program that is in progress in the refining, natural gasoline and petrochemical industry. For a year and a half it has appeared as an exclusive feature in PETROLEUM REFINER and it has proved a valuable aid and guide to our readers.

Companies whose projects are not listed or readers who know of projects not listed are urged to: 1) send in data, as called for by the column headings, on units not shown herein; 2) furnish details which are missing in any items in the current tabulation, and 3) report from time to time on the progress of these projects. Address, Editor, PETROLEUM REFINER, Box 2608, Houston 1, Texas. Such cooperation will be very much appreciated.

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
EAST									
Esso Standard Oil	Linden, N.J.	Vac. pipe still	40,000 bbls.	.....	Under Constr.	1st Qtr., 1949	.....	S.O.D. & Braun	Braun
Esso Standard Oil	Linden, N.J.	Cat. Crack, Light Ends	41,000 bbls.	.....	Under Constr.	2nd Qtr., 1949	.....	S.O.D., Braun	Braun
Esso Standard Oil	Bayonne, N.J.	Dewaxing	7,500 bbls.	.....	Under Constr.	1st Qtr., 1950	Texaco	Badger	Badger
Esso Standard Oil Co.	Linden, N.J.	Steam Boiler	260,000 lbs. hr.	.....	Under Constr.	1st Qtr., 1949	.....	S. O. D.	.....
Esso Standard Oil Co.	Bayonne, N.J.	Steam Boilers	400,000 lbs. hr.	.....	Under Constr.	2nd Qtr., 1950	.....	S. O. D., Day & Zimmermann	S. O. D., Day & Zimmermann
Gulf Oil Corp.	Philadelphia, Pa.	Topping and Vacuum Unit	30,000 bbls.	.....	Under Constr.	Sept., 1949	.....	Lummus Badger	Lummus
*Gulf Oil Corp.	Philadelphia, Pa.	Expand Refinery	107,000 bbls.	$40 million	Projected	.....	.....	.....	.....
Socony-Vacuum Oil Co., Inc.	Paulsboro, N.J.	Crude, Dist. Unit	20,000 bbls.	.....	Under Constr.	Mid 1949	.....	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Propane Deasphalting	6,600 bbls.	.....	Under Constr.	Mid 1949	Juik	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Furfural Refg.	4,450 bbls.	.....	Under Constr.	Mid 1949	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	MEK Dewaxing	2,050 bbls.	.....	Under Constr.	Mid 1949	Texaco	Badger	Badger
Socony-Vacuum	Paulsboro, N.J.	Clay Contact Unit	.....	.....	Designing	Late, 1949	.....	Badger	Badger
Socony-Vacuum Oil Co. Inc	Paulsboro, N.J.	Light Oil Treating Plant	27,000 bbls.	.....	Designing	Mid 1949	.....	Badger	Badger
I. Sonneborn Sons, Inc.	Petrolia, Pa.	Enlarge Acid Plant Anti-Pollution	.....	$400,000	Under Constr.	Middle 1949	.....	Chemical Constr. Co	Morris Knowles & Co.
Sun Oil Co.	Marcus Hook, Pa.	Wax	.....	.....	Under Constr.	1949	Texaco	Staff	Staff
Sun Oil Co.	Marcus Hook	Comp. & Pkg.	.....	.....	Under Constr.	1949	.....	Staff—Lindsay	W. W. Lindsay
The Texas Co.	Beacon, N.Y.	Expand Research Labs.	.....	.....	Under Constr.	Oct., 1, 1949	.....	Voorhees, Walker, Foley & Smith	.....
The Texas Co.	Westville, N.J.	New Refinery	40,000 bbls.	.....	Under Constr.	July 1949	.....	Foster-Wheeler, Jackson-Moreland, Kellogg	Foster-Wheeler, Kellogg
Tide Water Associated Oil Co.	Bayonne, N.J.	Revamping Houdry Fixed Bed Unit	.....	.....	.....	Completed	Houdry	Houdry	Cat. Constr.
U. S. Dept. of Interior	Bruceton, Pa.	Fischer-Tropsch Pilot Plant (Coal-to-gasoline synthesis)	1-2 bbls	$150,000	Under Constr.	June, 1949	.....	Staff	Blaw-Knox Co.
MID-CONTINENT									
*Ashland Oil & Refining Co.	Canton, Ohio	Ref. Modernization	.....	.....	Under Constr.	Middle 1949	.....	.....	Cat. Constr.
Ashland Oil and Refining Co.	Ashland, Ky.	Revision & Modernization of Refg. Units	.....	$500,000	Under Constr.	1st Quarter, 1949	.....	Staff	Staff, Cat. Constr.
*The Carter Oil Co.	McKamie, Ark.	Pressure Maintenance Unit	38,000 mcf	.....	Under Constr.	July, 1949	.....	J. & L. Constr.	J. & L. Constr.
Cities Service Oil Co.	Chicago	Compounding & Grease Plant	1,200 bbls.	$2.5 million	Design	Late 1949	.....	Sumner-Sollitt	.....
Cooperative Refinery Association	Coffeyville, Kansas	Dewaxing	2,300 bbls.	$1.5 million	Contracted	1949	Texaco	Process Eng.	Process Eng.
Coopersitive Refinery Assoc.	Coffeyville, Kansas	Modernize Gasoline Plant	20,000 bbls.	$900,000	Under Constr.	June, 1949	U.O.P.	U.O.P., Staff	Staff
Continental Oil Co.	Ponca City, Oklahoma	Crude Dist. Unit	30,000 bbls.	.....	Under Constr.	Oct., 1949	.....	Bechtel	Bechtel
Dewese Oil Co.	Weston, Ohio	Lube Filtering Unit, Desalting	250 bbls.	$15,000	Under Constr.	Spring, 1949	.....	Staff	Staff
The Globe Oil & Refining Co.	Lemont, Ill.	Cat Cracker Unit	6,000 bbls.	$1 million	Buying Material	Jan. 1, 1950	U.O.P.	U.O.P.	.....
Gulf Refg. Co.	Toledo, Ohio	Top & Vac. Unit	32,000 bbls.	.....	Under Constr.	March, 1949	.....	Badger	Badger
Gulf Refg. Co.	Toledo, Ohio	Fluid Cat. Crk.	15,500 bbls.	.....	Under Constr.	May, 1949	.....	Kellogg	Kellogg
Gulf Refg. Co.	Toledo, Ohio	Poly Unit	5,000 bbls.	.....	Under Constr.	May, 1949	U.O.P.	Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati, Ohio	Fluid Unit	15,500 bbls.	.....	Under Constr.	June, 1949	.....	Kellogg	Kellogg
Gulf Refg. Co.	Cincinnati, Ohio	Polymer Plant	5,000 bbls.	.....	Under Constr.	June, 1949	U.O.P.	Kellogg	Kellogg
Hiwan Oil Co.	Magnolia, Ark.	Gasoline Plant	10,000 mcf	.....	Part Completed	.....	.....	Petro. Eng.	Petro. Eng.
Lion Oil Co.	El Dorado, Ark.	Enlarge Ammonia Unit	570 tons	$3.5 million	Under Constr.	June, 1949	.....	Chem. Constr.	Chem. Constr.



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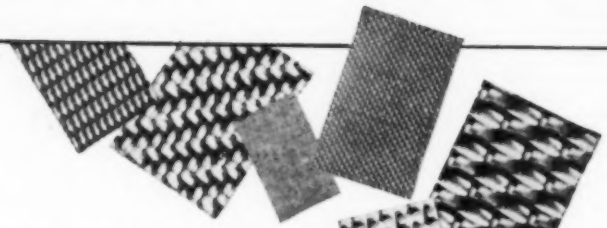

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Wire cloth made of Monel, Nickel or Inconel has extra strength to resist damage by heavy pressures; extra hardness to resist abrasive wear; extra endurance at high temperatures; extra protection for product purity.

It is rustproof; highly resistant to corrosion by most acids, alkalies and salts.

Compare its advantages with any fabric or metal cloth you are now using. Better yet, make a comparative-life test right in your own plant.

Even the cost is attractive. The easier working of these metals enables weavers to produce cloth of Monel, Nickel or Inconel at prices comparable to what you are now paying for less durable metals. *Fine weaves of Monel often cost less!*

Seams are easily brazed, *soldered or welded; retain full corrosion resistance. All weaves and meshes are available. Write Frank Bailey of Inco for booklet,* "ESTABLISHED WEAVERS."

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Lion Oil Co.	El Dorado, Ark.	Sulfuric Acid Plant	300 tons	$1¼ million	Under Constr.	Sept., 1949	.....	Chem. Constr.	Chem. Constr.
Lion Oil Co.	El Dorado, Ark.	Ammonium Sulfate Plant	380 tons	$750,000	Under Constr.	Sept., 1949	.....	Chem. Constr.	Chem. Constr., Blaw-Knox
M. F. A. Oil Co.	Chanute, Kans.	Desulfurization	1,000 bbls.	$75,000	Under Constr.	June, 1949	Phillips	Koch	Staff
Magnolia Pet. Co.	Grant County, Kans.,(Hickok)	Gasoline Plant	100,000 mcf	.....	Buying Material	Nov., 1949	.....	Staff	Walco
Magnolia Pet. Co.	Grady County, Oklahoma	Gasoline Plant	30,000 mcf	.....	Design	Sept., 1949	.....	.....	.....
Magnolia Petroleum Co.	Stephens County, Okla.	Gasoline Plant	30,000 mc	.....	Under Constr.	Jan., 1950	.....	.....	J. & L.
Mercury Oil Refining Co.	Oklahoma City, Oklahoma	Crude Unit	3,500 bbls.	$250,000	Under Constr.	Dec., 1949	.....	Ref. Eng.	Ref. Eng.
Midland Cooperative Wholesale	Cushing, Okla.	Thermal Reforming	1,400 bbls.	$500,000	.....	Completed	U.O.P.	U.O.P., Ref. Eng.	Ref. Eng.
*Midland Cooperative Wholes'le	Cushing, Okla	Cat. Poly Unit	200 bbls.	.....	Authorized	Middle, 1949	.....	.....	Ref. Eng., U.O.P.
Ohio Oil Co.	Robinson, Ill.	Vac. Unit Cat. Crack, Crude Still, Poly, LPG Recovery	27,500 bbls.	$15 million	Under Constr.	Early, 1949	U.O.P.	McKee	McKee, Pritchard
Peteo Corp.	Blue Island, Ill.	Houdriflow Cat. Cracker Unit, LPG Recovery System	5,000 bbls.	$400,000	Under Constr.	Last Quarter, 1949	Houdry	Houdry	Clark's
Phillips Pet. Co.	Kansas Cy, Kans.	Cat. Crack	24,000 bbls.	.....	Under Constr.	Oct., 1949	.....	Braun	Braun
Phillips Pet. Co.	Kansas Cy, Kans.	Cat. Poly	1,500 bbls.	.....	Under Constr.	Oct., 1949	.....	Braun	Braun
Phillips Pet. Co.	Guymon, Okla.	Absorption Plant	173,000 mcf	.....	Authorized	July, 1949	.....	.....	.....
*The Pure Oil Co.	Toledo, Ohio	Revamping Crude Reforming Units	.....	.....	Under Constr.	1st Qtr., 1949	.....	.....	Cat. Constr.
*R. J. Oil & Refining Co., Inc.	Princeton, Ind.	Electric Desalter	1500 bbls.	$15,000	Under Constr.	.....	Petro	State Eng.	State Eng
Rock Island Refg. Corp.	Rock Island, Ind.	Fluid Cat, Crk	10,000 bbls.	$1,200,000	Contracted	July, 1949	U.O.P.	U.O.P.	Staff
The Shallow Water Refining Co.	Shallow Water, Kansas	Reforming Unit	1,250 bbls.	$85,000	Under Constr.	Fall, 1949	Pureo	Koch Eng.	Koch Eng.
Skelly Oil Co.	Eldorado, Kans.	Crude Dist. Unit, Cat. Crk.	35,000 bbls.	.....	Under Constr.	Mid 1950	.....	.....	.....
Socony-Vacuum	E. St. Louis, Ill.	Crude Distillation	30,000 bbls.	.....	Under Constr.	Aug., 1949	.....	Bechtel, Staff	Bechtel
Socony-Vacuum Oil Co.	East St. Louis, Illinois	Thermal Cracking, Reforming, Visbreaker Unit	15,000 bbls.	.....	Under Constr.	Oct., 1949	.....	Staff, Bechtel	Bechtel
Socony-Vacuum Oil Co.	East St. Louis, Illinois	Tannin Solutioner Treating Unit	20,000 bbls.	.....	Under Constr.	June, 1949	.....	Staff, Bechtel	Bechtel
Socony-Vacuum Oil Co.	East St. Louis, Illinois	Miscl. Refinery Additions	.....	.....	Under Constr.	Sept., 1949	.....	Staff, Bechtel	Bechtel
Socony-Vacuum Oil Co.	East St. Louis, Illinois	Delayed Coking Unit	8,700 bbls.	.....	Under Constr.	.....	.....	Staff, Bechtel	Bechtel
Standard Oil Co., (Ohio)	Lima, Ohio	Lube Oil Solvent, Refining Plant	76,000 gals.	$13 million	Contracted	1951	.....	Kellogg, Lummus	Kellogg, Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Cat. Cracking	16,000 bbls.	$11 million	Under Constr.	Late 1949	U.O.P.	McKee	McKee
Standard Oil Co., (Ohio)	Lima, Ohio	Crude Distl., Coke	†15,000 bbls.	$5 million	Authorized	Mid 1950	Kellogg	Kellogg	Kellogg
Standard Oil Co., (Ohio)	Lima, Ohio	Solvent Extraction Dewaxing Unit	1,800 bbls. Finished Products	.....	Authorized	Mid 1950	Texaco	.....	Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Vacuum Unit	9,000 bbls.	.....	Authorized	Mid 1950	.....	.....	Lummus
Standard Oil Co., (Ohio)	Lima, Ohio	Propane Deasphalting Unit	800 bbls.	.....	Authorized	Mid 1950	.....	.....	Lummus
Stanolind O&G Co.	Ulysses, Kans.	Gasoline Plant	100,000 mcf	.....	.....	Completed	.....	J & L Constr.	J & L Constr.
Sun Oil Co.	Toledo, Ohio	Cat. Crack Crude Dist., Vac., Poly	30,000 bbls.	$16 million	Under Constr.	1950	Houdry	Houdry, Cat. Constr., Process Eng., Staff	Cat. Constr.
Sun Oil Co.	Toledo, Ohio	Anti-Pollution	600,000	.....	Under Constr.	1949	.....	Sun Oil	Cat. Constr.
The Texas Co.	W. Tulsa, Okla.	Crude and Cat. Cracking	30,000 bbls.	.....	Under Constr.	July, 1, 1949	.....	Kellogg, Foster-Wheeler, U.O.P.	Kellogg, Foster-Wheeler
The Texas Co.	Lawrenceville, Illinois	Expand Refinery	†20,000 bbls.	.....	Proposed	Jan. 1, 1951	.....	.....	.....
Tide Water Associated Oil Co.	Drumwright, Oklahoma	Houdriflow Unit Cat. Cracker	4,500 bbls.	.....	Contracted	.....	Houdry	.....	Process Eng.
U. S. Bureau of Mines	Louisiana, Mo.	Synthetic Liquid Fuels Plant	200 bbls.	$10 million	.....	Completed	.....	Staff, Bechtel	Bechtel
U. S. Dept. of Interior	Louisiana, Mo.	Demonstration Oil-from-Coal Plant	75 bbls.	$4.4 million	Under Constr.	Oct., 1949	.....	Koppers	Koppers
Warren Pet. Corp.	Mayaville, Okla.	Gasoline Plant	8,000 bbls.	.....	.....	Completed	.....	Dresser	Dresser
Wood River Oil & Refg. Co.	Hartford, Ill.	Cat. Cracking Gasoil,Cracking	8,500 bbls.	$1 million	.....	Completed	Phillips	Koch Eng.	Koch Eng
*Wood River Oil & Refining Co., Inc.	Hartford, Ill.	Vacuum Unit	15,000 bbls.	$700,000	Under Constr.	June, 1949	.....	Koch	Staff
*Wood River Oil & Refining Co., Inc.	Hartford, Ill.	Fluid Cat. Cracker	7500 bbls.	$2.5 million	Under Constr.	Dec., 1949	U.O.P.	Koch	Staff
SOUTHWEST									
The Athantic Refining Co.	Block 31, Crane County, Texas	Gas Injection Plant	8,320 mcf	.....	Under Constr.	May, 1949	.....	Hudson, Staff	Hudson
Barnsdall Oil Co.	West Tepetate Field, La.	Gasoline Plant	20,000 mcf	$800,000	Under Constr.	Middle 1949	.....	Dresser	Dresser
The California Co.	Brookhaven, Mississippi	Cycling Plant	10,000 mcf	.....	Designing	3rd Qtr., 1949	.....	Hudson	Hudson
Calumet Ref. Co.	Princeton, La.	Blending Oil Tank House	700 bbls.	.....	Under Constr.	3rd Qtr., 1949	.....	.....	Staff
Carthage Corp.	Carthage, Field	Gasoline Plant	250,000 mcf	$3.5 million	Under Constr.	March, 1949	.....	Hudson	Hudson
Carthage Hydrocol, Inc.	Brownsville, Texas	Hydrocol	87,000 mcf	$26 million	Under Constr.	Aug., 1949	Hydro-Res., Inc. Texaco	McKee, Hydro-Res., Inc.	McKee
The Chicago Corp.	Carthage, Texas	Enlarge Gas Plt	210,000 mcf	$2 million	Under Constr.	June, 1949	.....	Fish Eng.	Fish Eng.
Cit-Con Corp.	Lake Charles, La.	Lube Plant	6,000 bbls.	$35 million	Under Constr.	Oct., 1949	Texaco, Max B. Miller	Max B. Miller, Lummus	Lummus, Max B. Miller
Cities Service Oil Co.	Pampa, Texas	Gasoline Plant	18,000 mcf	.....	Contracted	1949	.....	Walco	Walco
Cities Service Oil Co.	Chico Field, Wise Co., Tex	Natural Gasoline Plant	22,000 mcf	.....	Planned	Early, 1950	.....	.....	.....
Claiborne Gasoline Co.	Lisbon, La.	Enlarge Gasoline Plant	125,000 mcf	.....	Under Constr.	March, 1949	.....	Pet. Eng.	.....

REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Continental Oil Co.	Todd (Deep) Field, Texas	Gas Recovery Plant	10,000 mcf	.....	Under Constr.	Sept., 1949	.....	Ref. Maint.	Ref. Maint.
Cosden Pet. Corp.	Big Spring, Tex.	Fluid Cat. Plant	6,000 bbls.	$2 million	Under Constr.	Nov., 1949	U.O.P.	U.O.P.	Ref. Eng.
*E. I. DuPont de Nemours Co., Inc.	Victoria, Tex.	Chemical Intermediates for Nylon	.....	.....	Design	Early 1951	.....	Staff	Staff
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends Recovery	20,000 mcf	.....	Under Constr.	1st Qtr., 1949	.....	S.O.D., McKee	McKee
Esso Standard Oil Co.	Baton Rouge, La.	Light Ends	11,000 bbls.	.....	Under Constr.	1st Qtr., 1949	.....	Braun	Braun
Ethyl Corp.	Baton Rouge, La.	Mfg. Facilities	.....	$40 million	Under Constr.	Oct., 1949	.....	Stone & Webster	Stone & Webster
Gray-Wolfe Co.	Montgomery Co.	Gasoline Plant	13,000 mcf	$2 million	Under Constr.	March, 1949	.....	O. L. Olsen	O. L. Olsen
Gulf Oil Corp.	Crane, Texas	Gasoline Plant	40,000 mcf	.....	Contracted	Fall, 1949	.....	Braun	Braun, W. D. Bowden
Humble O&R Co.	Katy, Texas	Add Propane, Absorption, refrigeration	Unchanged	$7 million	Under Constr.	Oct., 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Kelsey Field, Texas	Gas Injection Plant	18,000 mcf	$1,406,000	Under Constr.	May, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Borregas-Seeligson, Tijerina-Canales Fields, Texas	Gas Injection Plant	20,000 mcf	$1,336,000	.....	Completed	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Conroe, Texas	Add Absorption	30,000 mcf	$4,160,000	Under Constr.	Summer, 1949	.....	Stearns-Roger	Stearns-Roger
Humble O&R Co.	Heyser Field Texas	Gas Comp. Plant	23,000 mcf	.....	Under Constr.	April, 1949	.....	Belleo Ind. Piping Co.	Belleo Ind. Piping Co.
Humble O&R Co.	Opelousas, La.	Absorption Plant	110,000 mcf	$2,800,000	Under Constr.	Summer, 1949	.....	Hudson	Hudson
Humble O&R Co.	Pickton Field, Texas	Absorption Plant	18,000 mcf	$2,133,000	Under Constr.	June, 1949	.....	Fluor	Fluor
Humble O&R Co.	Baytown, Texas	Pipe Stills	45,000 bbls.	$5.8 million	Under Constr.	Late 1949	.....	Foster-Wheeler	Foster-Wheeler
Humble O&R Co.	Baytown, Texas	Lube Extraction	7,000 bbls.	$5.3 million	Under Constr.	Late 1949	.....	Kellogg	Kellogg
Humble O&R Co.	Flour Bluff Field, Texas	Compression Plant	12,000 mcf	.....	Under Constr.	April, 1949	.....	Tellepsen	Tellepsen
Humble O&R Co.	Imogene-Jourdanton-Charlotte Fields Texas	Compression Absorption Plt.	26,000 mcf	.....	Contracted	1949-1950	.....	.....	.....
Humble O&R Co.	Thompsons, N. Thompsons, S. Thompsons Field, Texas	Gas Compression Plant	18,500 mcf	.....	Under Constr.	June, 1949	.....	Brown Eng.	Brown Eng.
*Hutex Oil & Refining Co.	Hardin, Tex.	Fractionators for Solvents	1000 bbls.	$50,000	Buying Materials	July, 1949	.....	Staff	Staff
Jefferson Chem. Co.	Austin, Texas	Central Research Facilities	.....	.....	Under Constr.	Sept., 1949	.....	Staff	Staff
La Gloria Corp.	Falfurrias, Tex.	Casinghead Gas	20,000 mcf	.....	Under Constr.	May, 1949	.....	Hudson	Hudson
Lone Star Gas	Dallas, Texas	Hypersorption Plant	60 mcf	.....	Design & Eng.	1949	Union Oil Co.	Foster-Wheeler	Foster-Wheeler
Magnolia Pet. Co.	Beaumont, Tex.	Lube Plant	.....	.....	.....	Completed	Texaco	Lummus	Lummus
Magnolia Pet. Co.	Seeligson Field, Texas	Gasoline and Cycling	70,000 mcf Casinghead 150,000 mcf Cycled	.....	Under Constr.	Sept., 1949	.....	Hudson	Hudson
Magnolia Pet. Co.	Kilgore, Texas	Increase Propane Recovery	Unchanged	.....	Under Constr.	April, 1949	.....	Staff, Delta	Delta
Midland Gasoline Co.	Conroe Field, Texas	Enlarge Gasoline Plant	100,000 gals.	.....	Under Constr.	Dec., 1949	.....	Gaso. Plant	Gaso. Plant
Nueces Corp.	Agua Dulce Field, Texas	Gas Compression	.....	.....	Under Constr.	April, 1949	.....	.....	.....
*Odessa Natural Gasoline Co.	Odessa, Texas	Enlarge Gasoline Plant	65,000 gals.	$1 million	Under Constr	May, 1949	.....	J. & L. Constr.	J. & L. Constr.
Paluxy Asphalt Co.	Yazoo City, Mississippi	Gas Recovery Cat. Polymer Unit	3½ mcf	$250,000	.....	Completed	U.O.P.	Koch	Staff
Pan American Refining Corp.	Texas City, Texas	Expand chemical Research Facilities	.....	.....	Contracted	Jan., 1950	.....	Staff, H. K. Ferguson	Staff, H. K. Ferguson
*Pan American Refining Corp.	Texas City, Tex.	Revamping Crude Unit	.....	.....	Engineering	Late 1948	.....	Tellepsen	Tellepsen
Panhandle Producing & Refg. Co.	Wichita Falls, Texas	Cat. Cracker	1,500 bbls.	$1 million	Engineering	March, 1950	U.O.P.	U.O.P., J. & L. Constr.	J. & L. Constr.
Panhandle Producing & Ref. Co.	Agua Dulce, Texas	Gas Compressor	5,000 mcf	$200,000	.....	Completed	.....	Staff	D. C. Thompson
The Parade Co.	Runk County, Texas	Add Propane Recovery	18,000 mcf	$250,000	Under Constr.	March, 1949	.....	Hudson	Hudson
Petrol Refining, Inc.	Texas City, Texas	Crude Topping Units	50,000 bbls.	.....	Under Constr.	April 1, 1949	.....	Rust. Eng.	Rust. Eng.
Phillips Pet Co.	Alvin, Texas	Absorption Plant	120,000 mcf	.....	Authorised	Sept., 1949	.....	.....	.....
Phillips Pet. Co.	Etter, Texas	Petro-chem. Plant Increase	140,000 tons yr.	.....	Authorised	.....	.....	Chem. Constr.	.....
Phillips Pet. Co.	Goldsmith, Tex.	Add to Absorption Plant	40,000 mcf	.....	Under Constr.	April, 1949	.....	.....	.....
Plymouth Oil Co.	Rankin, Texas	Gas Compression, Absorp.	70,000 mcf	$5½ million	Under Constr.	1949-50	.....	.....	Hudson
The Pure Oil Co.	Nederland, Tex.	MEK Dewaxing Clay Contact	2,500 bbls.	.....	.....	Completed	Texaco	Lummus	Lummus
The Pure Oil Co.	Nederland, Tex.	MEK Deoiling	200 bbls.	.....	Under Constr.	Sept., 1949	Texaco	Lummus	Lummus
The Pure Oil Co.	Nederland, Tex.	Compound, Blending	1,600 bbls.	.....	.....	Completed	.....	Staff, Verne E. Alden	Stone-Webster
The Pure Oil Co.	Nederland, Tex.	Grease Plant	66,000 lbs.	.....	.....	Completed	.....	Staff, Verne E. Alden	Stone-Webster
Shamrock Oil & Gas Co.	Sunray, Texas	Increase Topping & Cracking Facilities	10,000 bbls.	$300,000	Under Constr.	3rd Qtr., 1949	U.O.P.	Staff	Staff
*Reichhold Chemicals, Inc.	Houston, Tex	Synthetic Resins Plant	.....	$500,000	Projected	.....	.....	.....	.....
Sid Richardson Gasoline Co.	Keystone Field, Texas	Gasoline Plant	107,000 mcf	.....	.....	Completed	.....	J. & L. Constr.	J. & L. Constr.
*Royal Pet. Co.	Corpus Christi, Tex.	Modernize Refinery	.....	$3 million	Under Constr.	.....	.....	.....	.....
Sinclair Prairie Oil Co.	Midway Lane Field, Texas	Gas Compression	.....	.....	Under Constr.	Early, 1949	.....	.....	.....
Shell Chem. Corp.	Houston, Texas	Extend Acetone Facilities	.....	.....	Under Constr.	Late 1949	.....	Braun	Braun
Shell Oil Co.	Notrees, Texas	Extension TXL Plant	30,000 mcf	.....	Under Constr.	Early 1950	.....	Brown & Root	Brown & Root
Skelly Oil Co.	Skellytown, Tex	Expand Gasoline Plant	.....	.....	Under Constr.	Fall, 1949	.....	.....	J. E. Carlson

ARSENICAL ADMIRALTY 439

today's standard, designed for long-life in refinery service

Amount of critical alloying elements is checked in the laboratory with the help of this grating-type spectograph.

Every Anaconda Condenser Tube must withstand the hydrostatic pressure test required by A.S.T.M. Specification B 111.

CONTAINING approximately 70% copper, 28.96% zinc, 1% tin and 0.04% arsenic, Arsenical Admiralty 439 is highly resistant to dezincification, general corrosion, attack by fresh, brackish or salt waters, sweet or sour crudes under pressures, velocities and temperatures normally encountered in refinery condensers and heat exchangers.

Several years of extensive research preceded the commercial production of Arsenical Admiralty Tubes which was begun in 1934. The consistently satisfactory performance of Arsenical Admiralty Tubes in crude and re-run stills, cracking and polymerization plants for the past 14 years has fully proved the effectiveness of arsenic as an inhibitor of dezincification and has fully substantiated laboratory test results.

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It is a function of the engineers of our Technical Department to assist tube users in the selection of the most economical alloy for any given set of operating conditions. Feel free to call on us. Publication B-2, giving detailed information on Tubes and Tube Sheet Alloys mailed on request. 48141

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Shell Oil Co.	Denver City, Texas	Gas Compression, Absorp. Addition	30,000 mcf		Under Constr.	Late, 1949		Fluor	Fluor
Southern Minerals Corp.	Stratton Field, Texas	Gas Compression Addition			Under Constr.	1st Qtr., 1949			
Stanolind O&G Co., Opr.	Fullerton Field, Texas	Gasoline Plant	55,000 mcf		Under Constr.	Jan., 1950		J & L Constr.	J & L Constr.
Stanolind O&G Co., Opr.	Slaughter, Hockley Co., Texas	Gasoline Plant	90,000 mcf			Completed		Braun	Braun
Stanolind O&G Co.	Brownsville, Tex.	Chemical Plant	120,000 lbs./yr.		Under Constr.	Jan. 1, 1950		Badger	Badger
Stanolind O&G Co.	Petlus, Texas	Cycling Plant	165,000 mcf		Under Constr.	May 1, 1949		J & L Constr.	J & L Constr.
Stanolind O&G Co.	Levelland Field, Texas	Gasoline Plant			Planned	1950		Brown & Root	Brown & Root
Stanolind O&G Co.	N. Cowden, Tex.	Gasoline Plant	75,000 mcf		Engineering	1950		Stearns-Roger	Stearns-Roger
Sun Oil Co.	Starr Co., Texas	Gasoline Plant	35,000 mcf	$4 million	Under Constr.	May, 1949	Pet. Eng.	Pet. Eng.	Pet. Eng.
Sun Oil Co.	Jameson Field, Coke County Texas	Gasoline Plant	10,000 mcf	Part of $12 million	Under Constr.	March, 1949		Pritchard	Pritchard
*Tex. Natl. Gas Corp. & Slick-Urschel Oil Co.	Rankin, Tex.	Gasoline Plant	55,000 mcf		Under Constr.	Late 1949		Tex. Natl. Gas Corp.	Tex. Natl. Gas Corp.
The Texas Co.	Port Arthur, Texas	Lube & Wax Additions	137,500 Crude 72,500 bbls. Oil		Under Constr.	April 1, 1949		Foster-Wheeler	Foster-Wheeler
The Texas Co.	LaBtte, La.	Expand Gasoline Plant	6,500 mcf					Hudson	Hudson
The Texas Co.	Port Arthur, Texas	Change to Linde, Solutizer Treating Facilities			Under Constr.	March 1, 1949		Foster-Wheeler	Foster-Wheeler
The Texas Co.	Ganado Field, Texas	Gas Compression			Under Constr.	July, 1949			
The Texas Co.	Tijerina-Canales Field, Texas	Gas Compression			Under Constr.	Oct., 1949			
The Texas Co.	Chalk-Hill Field, Texas	Gas Compression, Absorp.			Under Constr.	Late, 1949			
United Gas Co.	Carthage, Texas	2nd Gas Plant	100,000 mcf	$3.5 million	Under Constr.	July, 1949		Hudson	Hudson
U. S. Ind. Chemicals Co.	Brownsville, Texas	Petrochemical Plant			Contracted	1949		Badger	Badger
Waggoner Est. Ref.	Electra, Texas	Crack Unit Revisions		$250,000		Completed	U.O.P.	Ref. Eng.	Ref. Eng.
Warren Pet. Corp.	Hawkins, Texas	Add Plant	20,000 mcf			Completed		Gaso. Plant	Gaso. Plant.
Warren Pet. Corp.	Wichita Falls, Tex. (Madden Plant)	Gasoline Plant	35,000 gals.			Completed		Waleo	Waleo
ROCKY MOUNTAIN									
*American Gilsonite Co.	Bonanza, Utah	Gilsonite to Crude Oil Pilot Plant	300 tons	$300,000	Engineering	July, 1949		Staff	Staff
The Carter Oil Co.	Billings, Mont.	Crude Cat. Crk.	30,000 bbls.	$20 million	Under Constr.	3rd Qtr., 1949		U.O.P., S.O.D., Fluor	Fluor
Continental Oil Co.	Billings, Mont.	Complete Ref. Cat. Crack	7,500 bbls.	$1 million	Under Constr.	Oct., 1949	U.O.P.	U.O.P., J & L Constr.	J & L Constr.
Empire State Oil Co.	Thermopolis, Wyoming	Crude, Vacuum Units	5,000 bbls.	$325,000	Engineering Underway	May, 1949		Ref. Eng.	Ref. Eng.
Gulf Oil Corp.	Eunice, N. M.	Gasoline Plant	50,000 mcf		Under Constr.	Middle 1949		Hudson	Hudson
New Mexico Asphalt Refg. Co.	Artesia, N. M.	Crude Unit	7,500 bbls.	$350,000	Material being Received	May, 1949		Geo. Armistead	Staff
The Pure Oil Co.	Worland, Wyo.	Gasoline Plant			Projected				
Skelly Oil Co.	Lea County, N. M.	Expanding Gasoline Plant	60,000 gals.		Under Constr.	Mid 1949			J. E. Carlson
Socony-Vacuum	Casper, Wyo.	T C C	6,900 bbls.		Under Constr.	March, 1949		Staff	Cat. Constr.
Southern Union Gas Co.	Bloomfield, N. M.	Gasoline Plant	20,000 mcf	$1 million	Contracted	June, 1949		Ref. Maint.	Ref. Maint.
Standard Oil (Ind.)	Casper, Wyo.	Cat. Crack	8,000 bbls.		Under Constr.	Early 1949			Kellogg
Stanolind O&G Co.	Elk Basin, Wyo.	Gasoline Plant	12,000 mcf		Under Constr.	April, 1949		Stone & Webster	Stone & Webster
Texas Gulf Sulphur Co.	Worland, Wyo.	Sulfur Recovery Plant	30,000 mcf		Projected				
U. S. Bureau of Mines	Rifle, Colo.	Shale Oil Refy.	300 bbls.	$750,000	Under Constr.	April, 1949		Ref. Eng.	Ref. Enf.
Utah Oil Refg. Co.	Salt Lake City, Utah	Propane Desphalting	10,500 bbls.	$2.5 million		Completed		Kellogg	Kellogg
WEST COAST									
*Barnsdall Oil Co.	Newhall, Calif.	Gasoline Recovery Unit	40,000 mcf		Under Constr.	June, 1949		Ref. Maint.	Ref. Maint.
General Petroleum Corp.	Torrance, Calif.	TCC Furnace Expansion	4,000 bbls.		Under Constr.	Early 1949		Staff-Lummus	Lummus
Hercules Powder Co.	Hercules, Calif.	Ammonia Plant			Under Constr.	Summer 1949		Staff	Bechtel
Robt. S. Lytle, Opr.	Conlinga, Calif.	H_2S Removal	33,000 mcf	$175,000	Under Constr.	April, 1949	Fluor	Fluor	Fluor
Shell Chem. Corp.	Dominguez, Cal.	Add Acetone			Under Constr.	July, 1949		Braun	Braun
Shell Oil Co.	Wilmington, Cal.	Extend Cracking Plant Compressors			Under Constr.	Middle 1949		Fluor	Fluor
Shell Oil Co.	Wilmington, Cal.	Extend Tank Storage			Under Constr.	Middle 1949		Staff	Chicago Bridge & Iron Co.
Stancal Asphalt & Bituminals Co.	Portland, Ore.	Asphalt Packing Plant, Warehouse			Under Constr.	June, 1949		Staff	
Standard Oil Co. of Calif.	Bakersfield, Calif.	Crude Dist.	10,000 bbls.	$7.5 million	Under Constr.	Mid 1949	Braun	Braun	Braun
Standard Oil Co. of Calif.	Bakersfield, Calif.	Thermal, Crk., Gaso. Stabil. Gaso. Treating	9,000 bbls.		Under Constr.	Late 1949	U.O.P.	U.O.P.	Braun
Standard Oil Co. of Calif.	El Segundo, Cal.	Filling Plant Modernization		$2 million		Completed			
Standard Oil Co. of Calif.	El Segundo, Cal.	Cracked Naphtha Rerun Still	22,000 bbls.	$2.6 million	Contract let	Aug., 1949		Braun	Braun
Union Oil Co. of California	Oleum, Calif.	Asphalt Refined Oil Loading Facilities		$457,000	Contracted	1949		Early Constr.	Early Constr.
Union Oil Co. of California	Oleum, Calif.	Revision of Refining Facilities		$4.2 million	Engineering	1949		Parsons	Ref. Maint.
Union Oil Co. of California	Oleum, Calif.	Revise Lube, Dewax Units	1,900 bbls.	$1.7 million	Contracted	1949	Union Oil Co.	Kellogg	Kellogg

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Union Oil Co. of California	Oleum, Calif.	Improvements to Compound & Grease Facilities	.....	$1.2 million	Engineering	1949	.....	J. M. Montgomery & Co.	.....
Union Oil Co. of California	Oleum, Calif.	Duo-Sol Unit	6,000 bbls.	$2.9 million	Contracted	1949	Max Miller	Max Miller	Max Miller
Union Oil Co. of California	Oleum, Calif.	Tankage and Utilities	.....	$2 million	Contracted	1949	.....	Ehrhart & Arthur	Ref. Maint.
Union Oil Co. of California	Wilmington, Calif.	H_2S Recovery	30,000 bbls.	$200,000	Engineering	1949	No	Ehrhart & Arthur, Inc.	.....
FOREIGN									
Agwi Pet. Corp.	Fawley, Eng.	.....	120,000 bbls.	$140 million	Projected	1952	.....	.....	.....
Anglo-Iranian Oil.	Abadan, Iran	Gas Plant	25,000 mcf	$2 million	Under Constr.	1950	.....	Badger	Badger
Anglo-Iranian Oil.	Abadan, Iran	Cat. Craker	30,000 bbls.	.....	Under Constr.	.....	.....	Foster-Wheeler	Foster-Wheeler
Anglo-Iranian Oil.	Abadan, Iran	Lube Plant	400 bbls.	.....	Under Constr.	.....	Texaco	Badger	Badger
Anglo-Iranian Oil.	Isle of Grain, Thames and Medway Estuary, Eng.	Central Refining Unit	60,000 bbls.	$120 million	Planning	1952	Texaco (Lube Unit)	.....	.....
Anglo-Transvaal Consolidated Investment Co.	Vall River Union, South Africa	Synthetic Gasoline and Diesel Oil Plant	.....	$50-60 million	Contracted	.....	.....	Hydrocarbon Research	.....
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Crude Oil Stabilizer	300,000 bbls.	$4,800,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Abqaiq, Saudi Arabia	Steam Power Plant, etc.	20,000 kw	$9,400,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Ras Tanura, Saudi Arabia	Add Power Generating Unit	10,000 kw	$1,750,000	Under Constr.	July-Sept., 1949	.....	Staff and Fluor	Staff and Fluor
Arabian American Oil Co.	Ras Tanura, Saudi Arabia	Refinery Additions	.....	.....	Under Constr.	1949	.....	Bechtel	Bechtel
*Australian Shell Oil Co.	Geelong Victoria, Australia	New Refinery	.....	$4.8 million	Under Constr.	1951	.....	.....	.....
Azienda Generale Italiana Petroli	Rome, Italy	Add to Plant	24,000 bbls.	.....	Projected	.....	.....	.....	.....
Bahrein Pet. Co, Ltd.	Bahrein Island	Expansion Program	.....	$8.3 million	Under Constr.	Oct., 1949	.....	U.O.P., Bechtel	International, Bechtel, Inc.
Bahrein Pet. Co., Ltd.	Bahrein Island	Crude Still, Utilities	55,000 bbls.	$9.1 million	Planned	June, 1950	.....	Lummus, Bechtel	.....
Bataafsche Petroleum Maatschappij	Rotterdam-Pernis, Holland	Dewaxing Unit	60,000 bbls.	.....	.....	.....	Texaco (Dewax)	.....	.....
British-American Oil Co., Ltd.	Montreal East P. Q., Canada	Cat Cracking and Cat Poly	13,300 bbls.	.....	Under Constr.	August, 1949	Kellogg-U.O.P.	Kellogg	Kellogg
British Pet. Chem. Ltd.	Grangemouth, Scotland	Petro-Chem	.....	$20 million	Planned	.....	.....	S. & W. Badger	S. & W. Badger
Burmah Oil Co.	Burma	Furfural Plant	1,000 bbls.	$600,000	Designing	.....	Texaco	Badger	.....
Burmah Oil Co.	Syriam, Burma	Thermafor Clay Revivification	66 tons	$150,000	Design	1949	Max Miller, Socony-Vacuum	Max Miller	.....
California-Texas Co., Ltd.	Cartagena, Spain	Refinery	15,000-30,000 bbls.	.....	Proposed	March, 1951	.....	.....	.....
Caltex Pet. Maatschappij, N. V.	Rotterdam, Holland	Complete	20,000 bbls.	$18 million	Under Constr.	Early 1950	.....	McKee, Badger, U.O.P.	McKee
Cie. de Reffinage Shell-Berre	Berre, France	Capacity Increase	47,000 bbls.	.....	Planned	.....	.....	.....	.....
Cie. Française de Raffinage	Gonfreville, France	Lube Unit	2,500 bbls.	.....	Projected	1951	.....	.....	.....
Cie. Française de Raffinage	Gonfreville, France	Distillation Unit	20,000 bbls.	.....	Under Constr.	1950	.....	Foster-Wheeler	Foster-Wheeler
Cie. Française de Raffinage	Provence, France	Topping Unit	20,000 bbls.	.....	Under Constr.	1950	.....	Foster-Wheeler	Foster-Wheeler
Cie Française de Raffinage	Provence, France	Lube Oil Unit	2,500 bbls.	.....	.....	1950	.....	.....	.....
Cie. Industrielle des Petroles	Frontignan, France	Capacity Increase	12,500 bbls.	.....	Under Constr.	.....	.....	.....	.....
Cie de Raffinage Shell-Berre	Petit Couronne, France	Lube Unit	.....	.....	Planned	.....	.....	.....	.....
Compania Espanola de Petróleos S.A. (C.E.P. S.A.)	Canary Islands, Spain	Lube, Wax Facilities	5,000 bbls.	$4½ million	Under Constr.	Early 1950	Texaco, Standard, N. J.	Foster Wheeler	Foster-Wheeler
Conselho National do Petróleo	Santos, Brazil	Complete Refinery	30,000 bbls.	$30 million	Projected	.....	.....	.....	.....
Consolidated Ref. Ltd.	Haifa, Palestine	Crude Plant	80,000 bbls.	.....	Planned	By 1950	.....	Badger	Badger
Consolidated Ref. Ltd.	Haifa, Palestine	General Facilities	.....	.....	Under Design	.....	.....	Badger, Ltd.	.....
Consolidated Ref. Ltd.	Haifa, Palestine	Lube Plant	2,500 bbls.	.....	Designing	.....	Texaco, Juik	Lummus, Kellogg	Lummus, Kellogg
Creole Pet. Corp.	Amuay Bay, Venezuela	Crude Stills	60,000 bbls.	$175 million	Under Constr.	1951	.....	S. O. Devel. Co.	Foster-Wheeler, J. G. White
Creole Pet. Corp.	Mulata Field, Venezuela	Stabilization and Repressuring Plants	20,000 bbls. oil 60,000 mcf gas	$4.2 million	.....	Completed	.....	Braun	Braun
Creole Pet. Corp.	El Roble Field, Venezuela	Repressuring	.....	.....	Planning	.....	.....	.....	.....
Egyptian Government	Cairo, Egypt	Crude Plant	.....	.....	.....	.....	.....	Lummus	Lummus
Hi-Way Refineries, Ltd.	Saskatoon, Saskatchewan	Crude Topping Unit	2,000 bbls.	.....	Under Constr.	.....	.....	Ref. Eng.	Ref. Eng.
Hi-Way Refineries, Ltd.	Saskatoon, Saskatchewan	Thermal Cracking Unit	500 bbls.	.....	Under Constr.	.....	.....	Ref. Eng.	Ref. Eng.
Imperial Oil, Ltd.	Edmonton, Canada	Increase Capacity	11,000 bbls.	$2½ million	Under Constr.	Sept., 1949	.....	Staff, Barnes	Barnes
Imperial Oil, Ltd.	Leduc Field, Canada	Gas Absorption Plant	24,000 mcf	$6.5 million	Under Constr.	1950	.....	Braun	Braun
Industrie Chimiche Italiane Petroli	Mantua, Italy	Crude	4,500 bbls.	.....	.....	.....	.....	.....	.....
Kuwait Oil Co.	Kuwait	Topping Unit	20,000 bbls.	$2 million	Under Constr. "Paper stage"	.....	.....	Badger	Badger
Mediterranean Ref. Co.	Trans-Arabian P.L. Mediterranean Term.	Refinery	.....	.....	.....	.....	.....	.....	.....
Mene Grande Oil Co.	West Guara, Venezuela	Repressuring	.....	.....	.....	.....	.....	.....	.....
National Oil Refineries, Ltd.	Llandarcy, Wales	Crude and Reform.	40,000 bbls.	$36 million	Designing	.....	.....	Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	Lubes & Wax	1,200 bbls.			.....	Texaco	Badger	Badger
National Oil Refineries, Ltd.	Llandarcy, Wales	SO_2 Solvent Extraction	3,000 bbls.	.....	Contracted	.....	.....	H. W. P.	.....
Pechelbronn S. A. E. M.	Merkwiller, France	Capacity Increase	1,550 bbls.	.....	Authorized	1950	.....	.....	.....

THINGS YOU CAN'T CALCULATE ON YOUR SLIDE RULE

Engineering problems solved in the laboratory are problems no longer — yet in steel and alloy plate fabrication there are factors where the right answers yield more readily to common sense than to the slide rule.

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REFINERY AND OTHER PLANT CONSTRUCTION (Continued)

COMPANY	Plant Site	Project	Daily Capacity	Estimated Cost	Status	Probable Completion	Licensor	Engineering	Contractor
Petro Carbon, Ltd.	Partington, England	Cat. Cracker Lube & Reform	20,000 bbls.	.....	.....	.....	.....	.....	.....
Petro Chem., Ltd.	Partington, England	Petro Chemicals	.....	.....	.....	.....	.....	.....	.....
Petróleos Mexicanos	Poza Rica, Mex.	Gas Purification, Pressure Maintenance, etc.	.....	$13 million	Contracted	Early 1950	.....	McKee	McKee
Petróleos Mexicanos	Salamanca, Mex.	Crude, Gasoil, Cracking	30,000 bbls.	$12 million	Under Constr.	Early 1950	U.O.P.	McKee	McKee
Phillblack, Ltd.	Avonmouth, England	Carbon Black Plant	50 million lbs. Yearly	$5 million	Contracted	1950	Phillips	H. W. P.	H. W. P.
Porto Marghera Rfg.	Venice, Italy	Enlarging Crude Unit	.....	.....	Contracted	.....	.....	H. W. P.	H. W. P.
Raffineries de Pétrole de la Gironde	Ambes, France	Refinery	13,000 bbls.	$7.8 million	Under Constr.	Early 1950	.....	U.O.P., McKee	McKee
Raffineries Françaises de Pétrole de l'Atlantique	St. Nazaire, France	Consolidate Refineries	7,100 bbls.	.....	.....	.....	.....	.....	.....
Raffinerie di Napoli, S. p. A	Naples, Italy	Topping Unit	10,000 bbls.	.....	Under Constr.	Early 1949	.....	Staff	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Contact Plant	.....	.....	Under Constr.	Mid 1949	.....	Staff	Sta
Olii Minerali Raffineries di Napoli, S. p. A.	Naples, Italy	Furfural Unit	1,000 bbls.	.....	Under Constr.	Early 1950	Texaco	Staff	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	MEK Unit	1,000 bbls.	.....	Design	Early 1950	Texaco	Lummus	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Deasphalting Unit	1,100 bbls.	.....	Design	Mid 1950	Tuik	Lummus	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Furfural Unit	1,000 bbls.	.....	Under Constr.	Early 1949	Texaco	Staff	Staff
Raffineries de la Vacuum Oil Co.	Notre Dame de Gravenchon, France	Grease and Compounding Plant	.....	.....	Under Constr.	Early 1950	.....	Staff	Staff
Régie Autònome des Petroles	Boussens, France	Absorption Plant	42,000 mcf	$2 million	.....	Completed	.....	Hudson	Etablissements
*Richmond Exploration Co.	Lake Maracaibo, Venezuela	New Refinery	35,000 bbls	.....	Engineering	June, 1950	.....	.....	.....
Scottish Oil, Ltd.	Grangemouth, Scotland	Crude	28,000 bbls.	$28 million	Designing	.....	.....	.....	Schneider
Scottish Oils, Ltd.	Grangemouth, Scotland	Cat. Crk.	5,000 bbls.		Planned	.....	.....	.....	.....
Shell Chem. Corp.	Thornton, Eng.	Petro-chem	.....	Several millions	Under Constr.	.....	.....	.....	.....
Shell Chem. Corp.	Shell Haven, England	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Chem. Corp.†	Stanlow, Eng.	Petro-chem	.....	.....	.....	.....	.....	.....	.....
Shell Oil Co. of British Columbia	Shellburn Ref., Vancouver	Add Crude Distillation	7,500 bbls.	$600,000	Under Constr.	March, 1949	.....	Staff	Staff
Shell Oil Co. (Venezuela)	Puerto Cardón, Venezuela	Complete Refg.	50,000 bbls.	.....	Under Constr.	Early 1949	.....	Lummus	Lummus
Shell Oil Co.	Heysham, Eng.	Remodel & Redesign Crude Plant	30,000 bbls.	.....	Under Constr.	Mid 1949	.....	.....	.....
Société Generale des Huiles de Pétrole	L'Avera, France	LPG and Gas Stabilizing Units	.....	.....	Under Constr.	.....	.....	.....	.....
Société Generale des Huiles de Pétrole	Dunkirk, France	Crude Reform.	33,000 bbls.	.....	Designing	.....	.....	.....	.....
Société Generale des Huiles de Pétrole	Dunkirk, France	Lube & Wax	6,700 bbls.	.....	Designing	1950	Texaco	.....	.....
Societe Industriel Belgique de Petréle	Antwerp, Beguim	Crude, Cracking Reforming	30,000 bbls.	.....	Designing	Mid., 1951	.....	.....	.....
Societa per Azioni Raffineria Padana Olii Minerali	San Matrino di Trecate, Italy	Refinery	10,000 bbls.	.....	Proposed	.....	.....	.....	.....
Standard Françaises des Pétroles	Port Jerome, France	Capacity Increase	30,000 bbls.	.....	Authorized	.....	.....	.....	.....
Standard Françaises des Pétroles	Port Jerome, France	Dewaxing Plant	1,000 bbls.	.....	Planned	.....	.....	.....	.....
Standard Françaises des Pétroles	Port Jerome, France	Deasphalting Plant	2,000 bbls.	.....	Planned	.....	.....	.....	.....
Stora Kopparberg	Sweden	Crude, Ther. Cracking	.....	.....	.....	.....	.....	Lummus	Lummus
Trent Oil Prod. Development Co.	North Shields, England	Crude Plant	11,500 bbls.	$4 to $8 million	Plans approved	.....	.....	.....	.....
*Union Petrol Refinery, Ltd.	Johannesburg, Union of South Africa	New Refinery	.....	$20 million	Projected	.....	.....	.....	.....
Venezuelan Pet. Co. (Sinclair)	Puerto la Cruz, Venezuela	Refinery	35,000 bbls.	.....	Clearing site	.....	.....	.....	.....
*Yacimientos Petroliferos Fiscales	Buenos Aires, Argentina	New Refinery	28,000 bbls.	.....	Engineering	Late 1950	.....	Kellogg	Kellogg
Yacimientos Petroliferos Fiscales	La Plata, Argentina	Crude Topping, Gaso Treating	50,000 bbls.	$2.8 million	Under Constr.	Early 1949	.....	Houdry Process Cat. Constr.	Cat. Constr.
Yacimientos Petroliferos Fiscales Bolivianos	Sucre, Boliva	Crude Plant	3,000 bbls.	.....	.....	2nd Qtr., 1949	.....	Foster-Wheeler	Foster-Wheeler
YPF Bolivianos	Cochabamba, Bolivia	Topping & Reforming Units	5,000 bbls.	.....	.....	1st Qtr., 1950	.....	Foster-Wheeler	Foster-Wheeler

* First appearance in tabulation. † Added capacity.

NOTE—Badger—E. B. Badger and Sons. Barnes—W. M. Barnes & Co. Bechtel—Bechtel Corp. Bellows—W. S. Bellows Co. Braun—C. F. Braun Co. Cat. Constr.—Catalytic Construction Co. Chem. Constr.—Chemical Construction Co. Clark's—Clark's Construction and Engineering Co. Dresser—Dresser Engineering Corp. Fish Eng.—Fish Engineering Corp. Fluor—Fluor Corp. Gaso. Plant—Gasoline Plant Construction Co. General American—General American Transportation Co. Houdry—Houdry Corp. Hudson—Hudson Engineering Corp. H. W. P.—Head Wrightson Processes, Ltd. Hydro Res.—Hydrocarbon Research, Inc. Ind. Eng.—Industrial Engineers, Inc. J. & L. Constr.—Construction Division, Jones & Laughlin Supply Co. Kellogg—M. W. Kellogg Co. Koch Eng.—Koch Engineering Co. Koppers—Koppers Co., Inc. Leonard—Leonard Construction Co. Lummus—The Lummus Co. Mason—Mason Brothers Construction Co. McKee—Arthur G. McKee Co. Mid-Continent—Mid-Continent Engineering Co. Max Miller—Max B. Miller & Co. Parsons—The Ralph M. Parsons Co. Pet. Eng.—Petroleum Engineering, Inc. Petro—Petroleum Rectifying Co. Pritchard—J. F. Pritchard Co. Process Eng.—Process Engineers, Inc. Ref. Eng.—Refinery Engineering Co. Ref. Maint.—Refinery Maintenance Co., Inc. S. O. D.—Standard Oil Development Co. Stearns-Roger—Stearns-Roger Manufacturing Co. Tellepsen—Tellepsen Construction Co. Texaco—Texaco Development Co. U. O. P.—Universal Oil Products Co. Walco—Walco Engineering. Wohfeld—Wohfeld Construction Co. Equally owned by California Texas Corp. and Socony-Vacuum Oil Co., Inc.

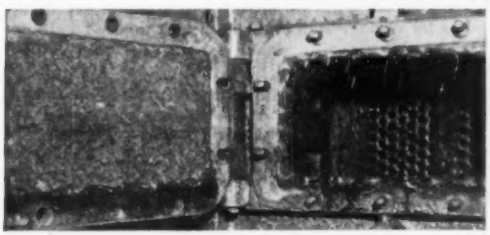
Reducing Scale and Slime

For Better Heat Transfer and Longer Tube Life

In petroleum refineries, petro-chemical and chemical plants the heat transfer rate of condensers and heat exchangers frequently is seriously reduced by the accumulation of foreign matter in the tubes. Seaboard plants may have slime, marine organisms and corrosion scale. Plants using inland waters are troubled by slime as well as various types of corrosion and mineral scales.

Slime and Marine Organisms. Algae, bacteria and foreign matter may accumulate on tube walls in the form of a tenacious slime or deposit. This condition varies with water temperature, suspended matter and with the nature of pollution from sewage and industrial wastes. Slime reduces heat transfer and, in seaboard plants, makes it easier for marine organisms to attach themselves to the tube walls.

Despite the use of screens, tiny organisms find their way into heat exchanger tubing, grow at a surprising rate and may soon impede water circulation. Marine organisms attached to water boxes or piping may be knocked loose and plug the tubes.



Marine growth on condenser water box and tube sheet in Gulf Coast installation.

In estuaries where the salinity of water varies widely with the seasons, mussels and barnacles may be killed during periods of fresh water and their shells drawn into the tubes.

Deposits of solid substances, such as shells, may lead to corrosion pitting, and also may deflect cooling water against the tube wall, causing impingement corrosion.

Corrosion Scale. Some protective corrosion product or mineral deposit is desirable on heat exchanger and condenser tubing, but excessive scale reduces heat transfer. Waters containing critical amounts of calcium carbonate may deposit a thick calcium carbonate scale on tubing. In some Western and Southwestern areas heavy silicate and calcium sulphate scales are formed, which are difficult to remove.

Copper in clean sea water develops a layer-type scale of copper salts and cuprous oxide. Harbor water containing minute traces of hydrogen sulphide leads to a marked increase in scale thickness. Sea water at moderately high temperatures may form a thick calcium-magnesium carbonate scale on copper evaporator tubes.

Cleaning Methods. The choice of cleaning method depends upon local conditions. Some heat exchangers are dried out, and the peeling algae-type films are blown or washed out of the tubes. In many cases rubber plugs are forced through the tubes by high pressure streams of water. Some scales are knocked loose by steam jets. Where heavy scales are troublesome, particularly in evaporators, the tubing may be installed in a bowed position. As the temperature of the metal rises and falls, the tubes bend back and forth, flaking off the scale.

Chemical cleaning methods include the use of solutions of chlorine, chloramine or hypochlorite, but excessive exposure and injury to protective films should be avoided. Inhibited acids are used, which are designed to attack the mineral scale but not the tubes.

Effect of Alloy Composition. Copper and its alloys are much more resistant to slime and marine growths than are aluminum, steel and concrete because copper salts retard marine growths. The more corrosion-resisting alloys, such as Cupro Nickel, Duronze IV* (Arsenical Aluminum Bronze), and Aluminum Brass, which dissolve the least, are more susceptible to biofouling than Admiralty and Copper.

Consult Laboratory. Contact the nearest Bridgeport office for laboratory service regarding problems of longer tube life, improved heat transfer and reduced maintenance. Bridgeport manufactures a wide range of corrosion-resisting tube alloys, as well as Duplex Tubing of Copper or a copper-base alloy on one side and steel, stainless, aluminum, Monel or nickel on the other. Write for 120-page Condenser Tube Manual.

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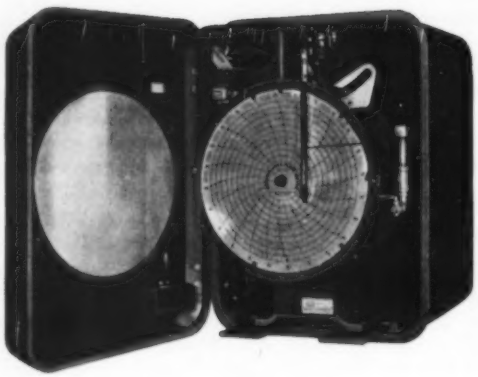

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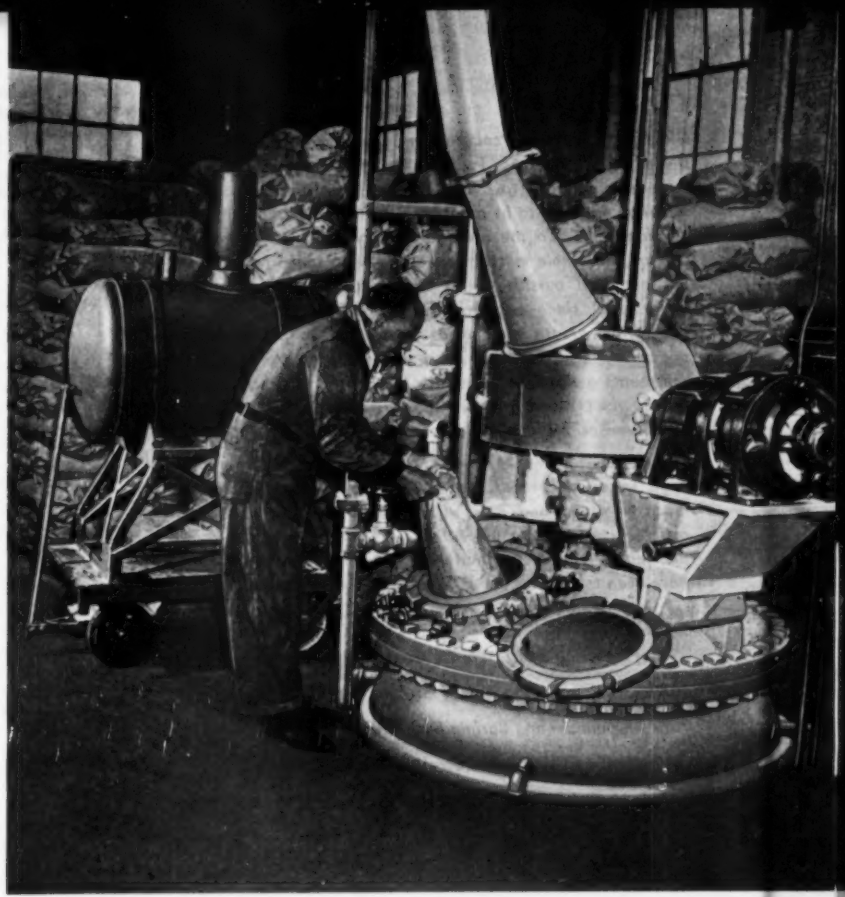


Charging Pressure Kettle for Production of Lime Base Grease at Sarnia, Ontario, Plant.
(Photo Courtesy Imperial Oil Ltd.)

The Manufacture of Lubricating Grease

PART I—Introduction

C. J. BONER
Chief Research Chemist, Battenfeld Grease & Oil Corporation
Kansas City, Mo.

With the advent of the "Industrial Age" it was found that liquid lubricants, or even lubricants which melted at summer temperatures, such as tallow, were not satisfactory for all purposes. What was desired was a lubricant which would function at elevated temperatures, stay in place for longer periods, act as a seal against the entrance of dirt and dust and not escape even if bearing seals were poor.

It was found that if mineral oils were thickened with soaps these desired characteristics resulted. The first lubricating greases were no doubt produced by the action of lime on a solution of rosin oil in mineral oil. Soon other types of soaps were tried until today soaps from more than half a dozen different metallic bases and from every type of fat are employed in the manufacture of lubricating greases.

A modern machine designer immediately thinks of lubricating fittings

***GREASE MAKING** is counted by some authorities as one of the more ancient arts. Today, when most refinery operations have been reduced to a more-or-less scientific basis, grease making continues to be a complex and difficult though highly developed art. To the average refinery man not engaged in the art, the whole matter is likely to seem somewhat mysterious and well outside of his field. This attitude is easy to understand, since comparatively little information has appeared on grease making as contrasted to other refinery operations. On the other hand, the manufacture of greases represents a large scale use for lubricating oils, prime refinery products, and grease making itself offers attractive opportunities for many plants not now active in that field.*

It is believed by the editors, therefore, that a rather thorough review of present day grease making practice is very much in order, and it is with real plasure that this initial article of a series is presented. The author is a well-known and highly regarded authority in his field. Titles for the series have been tentatively set as follows:

I. Manufacture of Lubricating Grease, Introduction.

II. Processing Equipment for Grease Manufacture.

III. Calcium and Soda Base Greases.

IV. Aluminum and Barium Base Greases.

V. Lithium Base and Miscellaneous Greases.

Part II of the series is scheduled to appear in the April issue.

when he lays out his machine. Such fittings in turn point to the use of lubricating grease. Examine any automobile, truck or piece of farm machinery and you can see by the number of such fittings why lubricating grease manufacture is now big business. About 115 establishments in the United States currently manufacture lubricating greases. The production is well over a billion pounds annually, with less than a fifth of this going into export. It is interesting that grease sales amount to about six-tenths of a pound for each gallon of lubricating oil sold. Table 1 shows the relative distribution of oil and grease sales for 1947.

If consideration is given to the advantages of grease lubrication over oil lubrication one can readily see why lubricating grease is so widely employed and therefore manufactured in such quantities. Some of these advantages are: Less frequent application is necessary with grease; lubricating grease acts as a seal against the entrance of dirt and dust; dripping or spattering is almost eliminated when a machine is grease lubricated; less expensive seals are required for a grease lubricated bearing, further, seals which are effective in preventing oil leakage have the disadvantage of increasing friction and power consumption; grease will insure some lubrication even when a bearing is neglected for some time; if the proper lubricating grease is used it will cling to metal better than oil (Magg of Timken puts it this way, "Being heavier than oils, greases normally leave a better protective film on bearing surfaces for prevention of rust and corrosion under bad operating conditions"); grease is preferable under extreme operating conditions such as high temperatures, extreme pressures, low speeds, shock loading, bearings operating intermittently or reversing; where machine parts are badly worn, lubricating grease is the only means of providing lubrication, and in verticle bearings grease lubrication simplifies design.

While the ASTM defines a grease as *A combination of a petroleum product and a soap or a mixture of soaps, suitable for certain types of lubrication*, lubricating grease manufacturers are prone to classify all lubricants sold by the pound as greases. We will be equally liberal in our interpretation of the term "grease" in this series.

Plant Location

Lubricating greases being a tonnage product makes accessibility of raw materials and outlet for finished product within a reasonable range the prime factor in choosing a plant location. Since water transportation affords the lowest freight charges, many such plants are located near seaboard or on rivers. Production capacity is perhaps about evenly divided between plants located adjacent to or on refinery property and those entirely segregated. In the former case the grease plant has the advantage of the power and utilities as well as the maintenance crew of the refinery. Further, shipment of mixed carloads of oil and grease are possible. On the other hand, the fact that this business is somewhat of a specialty field permits the existence of many independent grease plants.

Raw Materials

The basic raw materials required for the manufacture of lubricating greases are soap stocks, saponifying agents and a diluent, which is almost universally mineral oil. To this list can be added preformed soaps, stabilizers, chemical additives and fillers.

Soap Stocks

While almost any type of fat will form a soap, which in turn will produce a lubricating grease of a sort, it has been found that animal fats, or derivatives of such fats, serve best for grease manufacture. The greater proportion of lubricating greases are made from inedible tallow or fats from hogs or rendering plants. These latter products are bought and sold as white or yellow grease, which denotes that they have a lower solidifying point or titer than tallow. At one time horse oil was prized as a soap stock for greases, but little of this is now available. A smaller amount of lubricating grease is made from cottonseed oil, castor oil and other vegetable oils. In addition some wool grease, sperm oil, hydrogenated fish oil, hydrogenated seed oils, rosin oil, naphthenic acids and synthetic fatty acids are employed.

Most fats are purchased on standards which limit the combined mois-

ture, impurities and unsaponifiable to one percent. They all contain a certain proportion of free fatty acids which are not objectionable as long as the fat has not developed rancidity or become dark in color. Where lubricants are produced from dark colored oils, brown greases are sometimes used but most fats used are cream or light yellow in color.

The supply of fats in England and on the Continent has been so restricted in recent years that the lubricating grease manufacturers of these countries have had to use a very large proportion of wool grease or wool grease fatty acids, mixed with low grade fats and supplemented with perhaps a little palm oil.

For some purposes fatty acids are preferable for soap stocks. (Fats consist of a combination of glycerine and fatty acids.) If fat is "split," glycerine is broken off and the acids remain. However, such fatty acids still contain some unsplit fat and, if produced by older methods, may be dark in color. For these reasons a large proportion of fatty acids are distilled before use. In so doing the color is improved and most of the unsplit fat is removed. Fatty acids may be divided into three general groups. First are the saturated acids, most of which are solids and which are stable against oxidation. Next, is oleic acid, a liquid which, while it is classed as an unsaturated acid, is fairly stable as regards oxidation. Finally, there are the oxygen-sensitive acids found in large amounts in drying oils which normally are liquid. This latter type of course is undesirable as a soap stock for lubricating greases. It has been found possible to harden the liquid acids by hydrogenation and at the same time make them stable against oxidation. Thus, the fatty acids of a partially hydrogenated cottonseed oil, a hydrogenated castor oil and hydrogenated fish oil and the acids derived from the same are employed as soap bases for grease manufacture.

Advantages of Fatty Acids

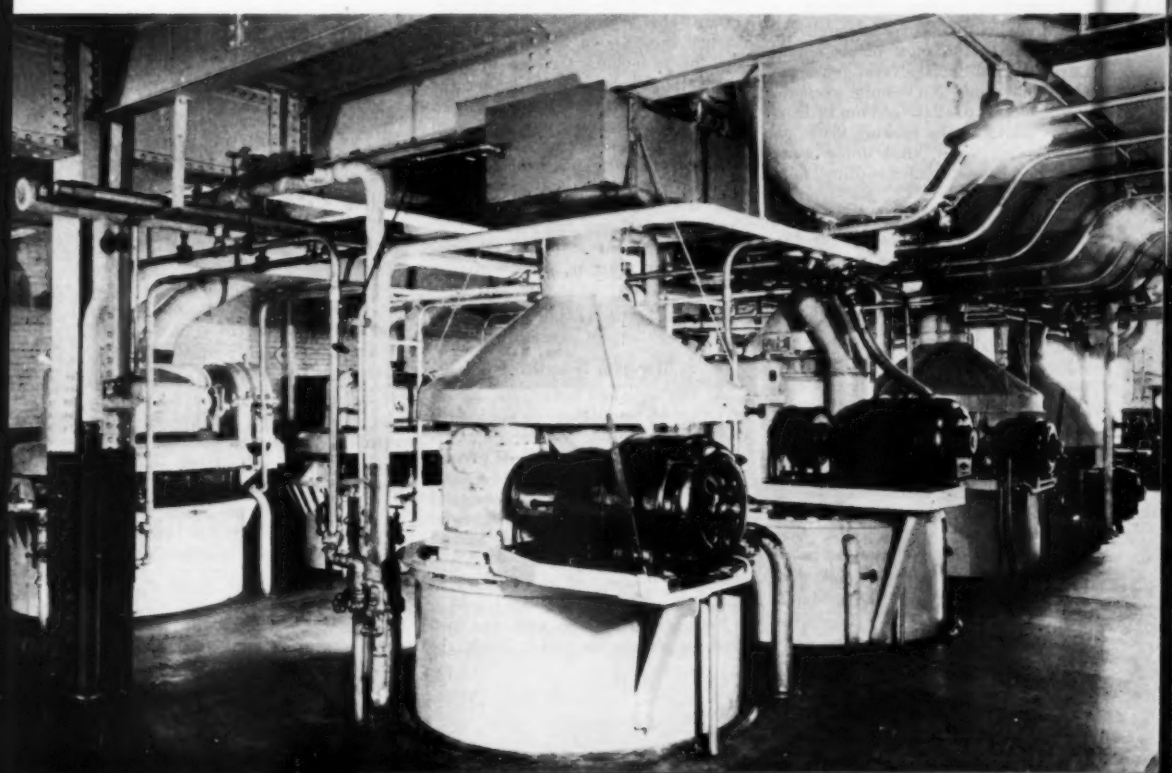
One of the advantages of the use of fatty acids is that after conversion of the fat to the acids it is possible to separate the various acids making up the mixture. Fats and the resulting fatty acids may contain from five to as many as ten different acids. In older processes the acids were chilled and pressed so that the liquid oleic acid was partly removed from the animal fatty acids. The hard cake remaining, known as stearic acid, was actually a mixture of two high melting point acids with a little oleic acid. Now fractionating processes, either vacuum or solvent, permit of still further and more complete separation.

Another advantage of the use of fatty acids is that they react with a saponifying agent more readily and completely than do fats. This may permit of soap formation at relatively low temperatures and in more dilute mixtures than in the case of fat.

Still another reason for the use of fatty acids is that certain special acids will give characteristics to the soaps not possible to obtain with fats. Thus, soaps produced from naphthenic acids and some synthetic fatty acids are more readily dispersed in mineral oils than other soaps.

Finally, when fat is used for the manufacture of a grease the glycerine set free remains in the final product and may have undesirable effects. Thus, glycerine tends to act as a flux for the soaps and will lower the melting point of the final product. This ingredient also influences the crystallization of some soaps adversely so that a firm grease will not result. This is particularly true of aluminum soaps, where a very small percentage of glycerine contributes to a livery na-

Equipment for Batch Process Grease Manufacture at Sarnia, Ontario.
(Photo Courtesy Imperial Oil Ltd.)



ture in a grease so that the product will never set to a firm gel. Also, greases containing glycerine will not be as transparent as those made from fatty acids.

Since glycerine broken off from fats by saponification remains in lubricating greases, this glycerine is lost to industry. During the last war the government appealed to lubricating grease manufacturers to increase their consumption of fatty acids and decrease that of fat so that a greater amount of glycerine would be available for explosive manufacture. Before the war about 30 percent of the fatty material used for grease manufacture was fatty acids. By 1943 the proportion of fatty acids used for this purpose was 45 percent.

Saponifying Agents

The saponifying agent is normally the hydroxide of the desired base or a compound which on mixing with water will be readily converted to the hydroxide.

Thus, for the manufacture of calcium base grease, hydrated lime is purchased. It is possible to purchase quicklime and slake it before use but we know of no case in which this has been practiced in recent years. A lime with only traces of silica and iron and very low magnesium content is preferable. All of this material should pass a 100-mesh screen and preferably 99 percent should pass a 300-mesh.

Sodium hydroxide may be purchased as a solution but most plants obtain this in a solid or flake form and make up lye solutions to a definite strength. In some cases the flake sodium hydroxide is added to the cooking kettle together with water, thus doing away with the necessity of handling solutions.

While some aluminum soaps for the manufacture of lubricating greases have been made by the reaction of aluminum hydroxide paste upon fatty acids, the current practice is to use preformed soaps which come as a fluffy powder.

Barium, lithium and strontium hydrates come as flakes or crystals containing some water of crystallization. They can be charged to the kettle in the form received or made into a solution before such addition.

These are the saponifying agents normally used. In case it is desired to produce a lead soap rather than purchase the same, litharge can be reacted with fatty material. Likewise, zinc oxide can be used in the manufacture of a zinc soap or the soap can be purchased.

Mineral Oils

Most lubricating greases are made from refined oils of pale or bright stock colors, although some cylinder stocks as well as dark residuums and even petrolatums are also employed. The types of oils used likewise vary. In most cases soaps disperse in naphthenic type oils more readily than in Pennsylvania or solvent types. Choice of oil is largely dictated by the use to which the grease will be put and the characteristics desired in the finished product. Thus, a grease to be used at very low temperature should have a low viscosity oil of low pour point. Likewise, a grease which will be subjected to prolonged use at elevated temperatures should be made from a high flash oil. The oils used may be as light as those having a viscosity of 50 @ 100 S. U. or they may be as heavy as residuums with a viscosity of 3000 @ 210 S. U. However, most of these oils will fall in the viscosity range of motor and truck engine oils.

Stability of the grease as regards resistance to oxidation will depend upon both the soap base and the mineral oil. Oils which are stable in this regard or which can be inhibited against oxidation are of course used for premium products.

Additives, Fillers, Etc.

Most additives used in lubricating greases are employed in relatively small amounts, but since they improve certain characteristics of the final product they are of decided interest. The theory behind the use of such materials will be covered under the specific types of greases so only a few of the classes of compounds used will be mentioned now. These may include higher alcohols, esters, organic amines, polybutene, sulfurized fatty materials, sulfur-chlorine compounds, dyes and, perfume materials.

Fillers include graphite, talc, asbestos, mica, alumina, powdered zinc, powdered lead, zinc oxide, red lead, carbon black, magnesium oxide and even fine silica.

Material Handling

As you will find later from the description of manufacturing equipment and operations, the volume of materials, other than oils, used in preparing lubricating greases only accounts for some 10 to 12 percent of the total tonnage. For this reason, material handling is not too involved in most grease plants.

Fat Handling

Fats, unless of high titer, are handled in drums or tanks. From the standpoint of economy and convenience, most users prefer to purchase in tank cars which are equipped with heating coils. Shipping, storage and handling of such materials is in steel, as a rule. While these fats do contain some fatty acids, the action on steel is slight if moisture is excluded. Heating coils should have all-welded joints because threaded joints fail quickly. Automatic regulation of the heat on storage tanks is wise since the material can be handled at 135° F. and high temperatures cause darkening. Pumps may be either reciprocating or centrifugal type. If these are in exposed locations a box covering with a very small steam coil inside may save trouble in cold weather.

Two-inch pipe will handle the volume required in most plants. Unless pipe lines are blown free after fat has been handled it is wise to place a steam "tracer" line alongside the pumping lines. Copper tubing, carrying low pressure steam, if placed next to the pipe inside the covering, is satisfactory. Since the higher melting point fractions may settle out of fat on standing, circulating lines for mixing the tank contents are provided. Scale tanks for weighing fat can be placed so as to permit gravity drainage. If this is done, heat can be provided by a bottom jacket so that complete drainage is assured. If the same weigh tank is used for both fat and fatty acids is should be constructed of stainless steel. Either flexible connections or couplings which can be broken easily should be provided at the weigh tank so that accurate weighing is possible.

The above plan also applies to fatty acid handling except that, in spite of the fact that most suppliers ship in steel tank cars, steel is not satisfactory at any stage of handling. Stainless steel or aluminum are the preferred materials for tanks. Glass or lead lined tanks also provide satisfactory storage and some tanks with a baked coating of a synthetic resin preparation are in use. Pipe lines, valves and pumps should likewise be of stainless steel, although where a positive displacement pump is required bronze end pumps are satisfactory. Duriron pumps will also serve for this material. Internal heating coils are not recommended for fatty acid storage tanks. In one case a stainless steel storage tank is set on 6-inch I beams and low pressure heating coils run between the beams. This tank is insulated with six inches of asbestos held by a metal form extending to the base on which the I beams rest. In another case copper tubing was wound around the out-

side of the tank and connected to low pressure steam, after which magnesite block insulation was added.

Bag Material Handling

The bag material handled in a grease manufacturing plant will include high titer fats or fatty acids, hydrated lime, barium hydrate and most fillers. Modern grease plants are of reinforced concrete construction with storage for a large part of their bag material on a top floor so that the flow will be downward as used. One such plant is four stories in height and has a large elevator to take all bag material, on pallets, to the top floor for storage. On this floor the ingredients are dumped into hoppers extending through to the third floor. Other plants make use of conveyors, as is the case with the handling of hydrated lime from a box car to a second story by a step conveyor.

From these storage hoppers the materials drop into weighing hoppers which are transferred on pallets to the desired kettle and dumped. Another modern plant has its weighing hoppers carried by suspended scales, moving on overhead rails. Some plants simply weigh each individual bag and empty direct into the kettle.

While most powder or flake material is charged in a dry state, many plants prefer to disperse some of these in a small portion of mineral oil before charging. Thus, hydrated lime may be premixed with a Lightning mixer in a small tank and the slurry added to the kettle. When fillers are added to compounding kettles considerable dust may be raised. For this reason one plant has provided a closed room where an oil slurry of materials such as graphite are prepared preliminary to addition to the kettles.

Some additives, fillers and saponifying agents are received in barrels or drums and these as well as preformed soap in cartons will be handled and weighed in a manner similar to bag material.

Oil Handling

Oil handling on a grease plant is little different from that on a refinery except that lesser amounts are handled. The storage tanks will vary in size from 8000 to 250,000 gallons capacity. In cold climates some of the tankage will be enclosed, particularly that used for heavy oils. Where a plant is so located that advantage is taken of water transportation during an open season, the storage capacity may be such as to take care of several months consumption. Since many of the oils are used intermittently, provision often is made to heat only the portion of the oil to be pumped, rather than keep the entire tankful hot. In one case two tube bundles were installed at the bottom of an outside storage tank. Each unit heats 40 gpm. of an oil of 90 SSU viscosity@ 210° F. from 30° to 140° F. when supplied with 50 psig. steam. In some cases oils must be blended before use, which is done in one of the storage tanks, mixing being by air. Some plants use calcium chloride drying units on breathers of oil storage tanks.

All oil piping in modern grease plants is entirely welded. Either two or three-inch lines normally supply the volume of oil required. Modern practice is to pump direct from storage to compounding kettles. For this purpose it is convenient to have electrically driven centrifugal or rotary gear pumps located at each storage tank with controls for the same on the operating platform. However, one plant, located where there is no freezing weather, has reciprocating pumps at the storage tanks and more uniform delivery to the compounding kettles is claimed. When positive delivery pumps such as rotary gear or reciprocating pumps are used, it is good practice to equip them with protective devices such as pressure relief valves, excess pressure governors, or pressure switches. With such equipment valves can be shut against operating pumps without damage or in some cases constant pressure can be maintained on a line. Almost all oils used in grease manufacture can be pumped at pressures under 50 psig., provided the oils have been warmed to a reasonable temperature and pipe lines are of adequate size. In other plants oils are pumped into run-down tanks so located that the contents will gravity into the kettles. Such tanks will vary in size from 600 to 2500 gallons capacity. While most plants use oil meters to gauge the delivery of oils, others provide for weighing, claiming greater accuracy. In this case two small tanks are set on scales, located so as to gravity into the kettle. This permits weighing in one while the other is being emptied. It is sometimes advantageous to provide a small oil heater adjacent to the compounding kettles so that the speed with which oil is added to the kettle can be increased.

TABLE 1
Sales of lubricating oil & greases, 1947
(Department of Commerce report)

CLASSIFICATION	OIL	GREASE		Pounds Per Gallon Oil
	42-Gallon Barrel	42-Gallon Barrel	Pounds	
Automotive—domestic	18,578,410	1,921,383	605,235,645	.775
Automotive—export	5,125,579	303,032	95,455,080	.443
Aviation—domestic	258,092	742	233,730	.021
Aviation—export	396,887	3,848	1,212,120	.73
Industrial—domestic	15,587,421	1,001,572	315,495,180	.482
Industrial—export	6,826,472	317,473	100,003,995	.349
GRAND TOTAL	46,772,861	3,548,050	1,117,635,750	.57

Types of Processing

Lubricating greases are manufactured by both batch and continuous processes.

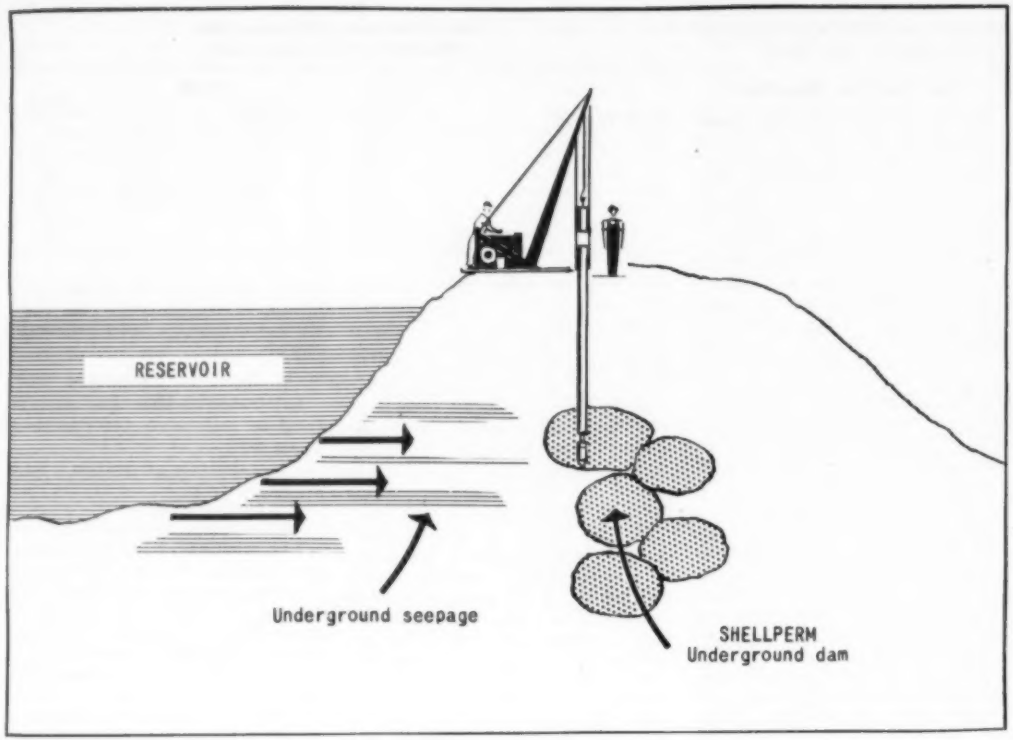
By far the larger proportion is made by the batch method, the amount made in one lot varying from a few hundred pounds to 60 or 100 barrels. A number of variations of the batch process are used. Thus, the soap required may be made from the ingredients or it may be purchased preformed. If saponification is carried on, this may be done at atmospheric pressure or in closed autoclaves under pressure. Further, the final grease may be made in the kettle in which saponification is carried out or it may be in a different vessel.

Probably the first continuous process for the manufacture of grease was applied to the production of axle grease. Since rosin oil when mixed with a slurry of hydrated lime will saponify in a matter of seconds or, at the most, a couple of minutes this reaction led itself readily to a continuous procedure. Hardly any other saponification required for production of the soaps employed in grease making can be carried out with such ease and therefore, considerable study and experimental work was required before other types of greases could be made continuously.

One process is now in use for the manufacture of aluminum and lithium base greases in which a ready-made soap is mixed in batch amounts and then processed to a finished grease in a continuous stream. Another process, used primarily for the production of calcium base grease, makes the soap batchwise and then carries on the rest of the manufacture in a continuous process.

Since equipment is tied in with specific processes, description of the two will be covered concurrently in the articles to follow.

End of Part I. Part II will appear in the April issue.



HOW IT WORKS—Sketch at top of page shows the use of "Shellperm" marketed by Shell Oil Company, Inc., an asphalt-in-water emulsion, to form an underground dam or barrier to prevent seepage loss of water from a reservoir through an earthen dam. After being pumped down through the pipe, which is driven into the ground, a chemical causes the emulsion to coalesce and form a barrier impermeable to water. According to the oil company, the process can be used effectively to prevent seepage of water without the use of more expensive methods as sheet piling.

Underground Dam

Injection of Asphalt-in-Water Emulsion Prevents Subsurface Seepage of Water

A PERMANENT underground dam may now be constructed through the use of an asphalt emulsion for the control of subsurface seepage, one of the chief causes of loss or pollution of water, according to an announcement made last month by Shell Oil Company, Inc.

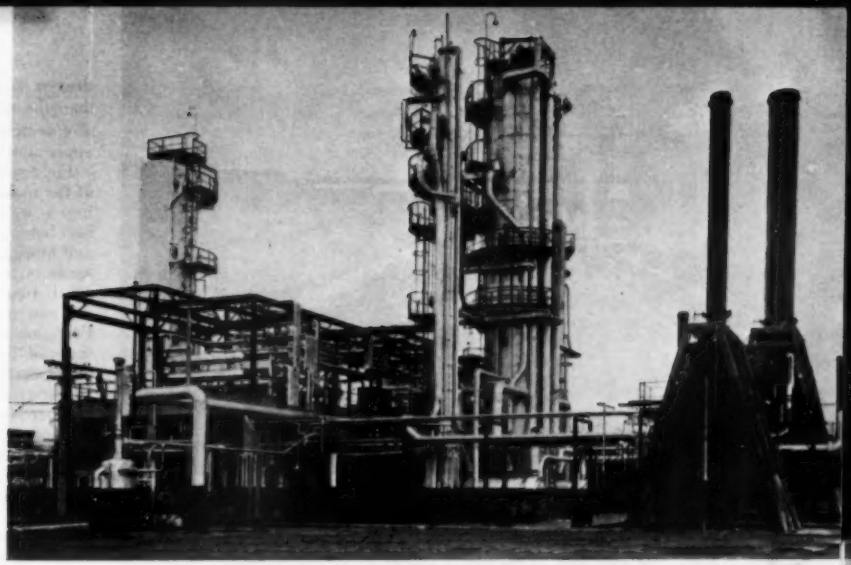
An underground barrier is built without excavating, by injecting the asphalt emulsion into the earth through a pipe. The new material under the trade name of "Shellperm" has been used to check serious loss of irrigation water through an earthern dam on the Santa Ana River in California.

Shellperm represents a landmark in the control of subsurface flow, the company said. The underground barrier formed by the material may prevent serious leakage of water through banks or reservoirs, check contamination caused by infiltration, and prevent sea water from seeping into fresh water wells.

In addition to its role in water conservation, Shellperm can also be used to check seepage around tunnels, road beds, or other subsurface structures, without the use of such relatively expensive techniques as sheet piling. The new process is especially significant, a Shell representative said, because heretofore control of underground movement of water has been costly and difficult at depths of more than a few feet.

Shellperm is a process employing an emulsion of asphalt in water, which is pumped under low pressure through a metal pipe driven into the ground. After the emulsion emerges from the pipe, it spreads out roughly in the form of a ball; then, chemicals mixed with the emulsion cause the asphalt to coalesce and the resulting mass is impermeable to water.

When the first or bottom injection has been made, the pipe is raised and additional Shellperm pumped down to form the second impermeable mass. Repeated injections produce a vertical asphalt column. The pipe is then moved and injections made to form a second vertical asphalt column. By repeating the process of building the overlapping or abutting vertical columns, an impermeable underground dam is formed.



A solvent extraction refining unit in the Port Arthur plant of Gulf Oil Corporation, Port Arthur, Texas. Protective coatings of high temperature resisting aluminum and black paint are used in this and the other solvent extraction units. Long life for economy is a "must" for these coatings.

Notes on a Refinery Paint Program

PART II

W. B. COOK, Plant Technologist

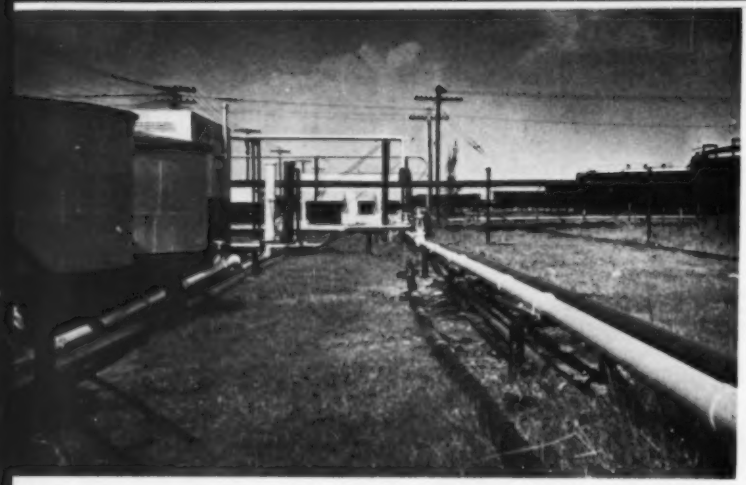
Gulf Oil Corporation, Port Arthur, Texas

***AS NOTED** in the first part of this article, a well planned paint program is an integral and important part of refinery maintenance, long recognized by managements as desirable, but not always attained in practice. In this second and final part of the article, the author completes a rather extensive set of notes, conclusions, and recommendations on the many problems of refinery painting, that should do much toward the clarification of a complex matter.*

VARIOUS types of surfaces require special consideration regarding the type of coating for provision of the best protection. The operating conditions of process equipment sometimes add to the complexity in the selection of the various types. For instance, metal surfaces such as aluminum and other alloys, requiring special types of primers for obtaining proper adhesion of the paint film, may be exposed to operating conditions of combined temperature and chemical exposure to which these special primers are not suited. Galvanized surfaces should be primed with paints containing a high percentage of zinc dust pigment for best adhesion, and since this pigment also affords good chemical resistance and is used quite extensively in high heat resistant coatings, selection of the proper coating for this type of surface is relatively simple.

Surfaces subjected to high temperature such as boiler fronts, breechings, stacks, flues, etc. require special heat resisting paints. Surface temperatures of various painted equipment in this refinery range from atmospheric to as high as 900° F. Totally satisfactory heat-resistant coatings have not yet been found but field testing is continuing. Since the predominant color scheme is aluminum, black, and gray, heat resistant paints must be one or another of these colors. Most process unit furnaces are painted black and a black heat resisting finish for stacks and breechings is desired. Heavy fuel oil tanks have black shells and are equipped with steam coils. Boiler fronts, breechings, blow-down stacks, pumps, and other hot equipment may be either black, aluminum, or gray, the color scheme depending on the color scheme of surrounding equipment and other factors.

Laboratory tests show high zinc dust content gray heat-resistant paints to be best, and low solids content aluminums next, but discoloration when exposed to weather and certain fumes to make a bad appearance are disadvantages of these. Black, bituminous types, some containing graphite and/or silicate compounds, are the most widely used of this color and although they withstand weather and fumes fairly well, the majority will not take the higher temperatures above 400 or 500° F.



The pipe lines in the right foreground and alongside the storage tanks on the left carry foam solution to various portions of the plant's tank storage farm for fire fighting. Color coding is used for convenient easy identification—the line appearing white is yellow and the line appearing dark is green. The paint used for the lines is selected by Gulf for permanency of color and protective qualities. Foam is pumped from the foam pump house, the rear of which can be seen behind the two storage tanks on the left.

Hot surfaces present a real coating problem. Pigments in these coatings should fuse to the metal to effect good adhesion but will not do this except at rather highly elevated temperatures. Primers should probably not be used at temperatures above 200° F. since they would not have the adhesion possessed by the heat-resistant coatings alone. Surface temperatures between approximately 200° F. and about 350° F., such as are encountered in steam heated tankage and on portions of breechings, pumps, etc. are too hot for use of most primers and not hot enough for fusion of heat resistant coatings to the metal. In these cases, Gilsonite or some coal tar paints appear to be the best selection.

Surfaces that are continuously hot will not corrode from atmospheric conditions unless exposed to certain chemical contact. Failure of most heat-resistant coatings occurs as a result of alternating hot and cold cycles. Some of the silicone resins are presently showing a great deal of promise for development of better high heat-resistant coatings, but these are so far prohibitively high priced and economically unsound since the most important function of high heat-resistant coatings is to simply afford better appearance due to the fact that with the absence of moisture very little rusting, if any, will occur.

Surfaces exposed to the various refinery chemical fumes are, to a large extent, also exposed to outside weathering and, in some cases, to petroleum vapors and/or liquids. Therefore, in service other than at some of the strictly chemical handling facilities, chemical resistant coatings must be also resistant to a wide range of petroleum products and the variable weather conditions. For usage in and on the different chemical processing and handling equipment, these coatings must also be resistant, as greatly as possible, to contact of the chemical itself in fume, liquid, or solid form as well as to variable weather.

For exterior exposure to some of the milder fumes such as hydrogen sulfide in low atmospheric concentration, it is now being recommended that lead-free zinc chromate type primers and under coats and lead-free pigmented alkyd resin types of finishes be used for greater durability, better appearance, and longer gloss retention than lead containing under coats and oil vehicle finish coats. Although primers and under coats containing lead pigments have been used considerably in the past in these areas, it is now thought that the H_2S reaction products formed are detrimental to both the durability and appearance of the completed job. Finish coats containing lead other than possibly a small amount of lead drier are avoided for application to surfaces exposed to hydrogen sulfide fumes, so far as is economically sound, due to chemical reaction discoloration.

Coal Tar Paint

On surfaces exposed to the more severe acid fumes such as in the sulfuric acid plant and other areas, an inexpensive coal tar paint has been used quite extensively. Although the durability of this product is not great, its low cost combined with relatively frequent recoating maintenance has proven so far to be more economical than the majority of the more expensive coatings that require more costly application.

Field test applications of a number of the so-called plastic vinyl type coatings as well as chlorinated rubber, rubber base synthetic, styrene, phenolic and other coal tar products, have been made on equipment in both acid and alkali fume and liquid exposures, and are now under observation and study. Economically, the combined disadvantages of low spreading rate, high material costs, and requirements of perfectly sand-blasted surfaces, multiple number of coats to afford sufficient film thickness, and high cost expert application workmanship factors connected with the vinyl type plastics appear to make them less desirable than some of the others, although their resistance to acid, alkali, petroleum products, and weather conditions is apparently extremely good.

Tank Interior a Special Problem

The interiors of storage tanks in sour crude and product service present a special corrosion problem. The vapor space surfaces are exposed to a combination of hydrogen sulfide, other sulfur and corrosive compound fumes, and petroleum vapors often containing a relatively large amount of aromatics of high solvency rating. Due to fluctuations in the liquid level, the vapor space varies up and down the shell and structural members, thus adding the requirement that the coating applied to the inside of the shell be also resistant to liquid petroleum. A totally satisfactory solution to this problem has been sought for many years, but as yet has not been found. A thick coal tar product containing asbestos fibre has been the most widely used type of product for this service, but the record of results obtained indicate doubt of the economic soundness of its continued use. Field test applications of rubberized synthetic resin, asbestos fibred natural bituminous gum, phenolic, phenolic modified vinyl, and straight vinyl coatings have been made and are now undergoing service tests. The interior tank surfaces are sand blasted to clean bright metal before application of any of these coatings. The vinyl coatings seem to be more promising than anything tried so far but since the total "life" of this type coating has not yet been definitely established, there is some doubt regarding the economic soundness of this rather high-priced application.

It is necessary to protect the steel bottoms of tanks in some of the sour oil services. Gunite is used quite extensively in the small run down sour

distillate tanks. In steel tank bottom repair work, a combination of tar paper and hot bituminus materials is sometimes used and these are sometimes also applied over old steel bottoms in conjunction with a layer of concrete.

Natural Oil Vehicle Types

Quite a large amount of equipment at this plant is located in areas relatively free of chemical fumes and the exterior of this is kept painted both for protection from the weather and for good appearance. In these areas lead pigmented natural oil vehicle pigmented finish coats are used mainly. Since the natural oil vehicle types of pigmented paints are more heavily bodied than the synthetics, making them practically fool-proof toward obtaining a good appearance, these types are used almost exclusively in these areas where the equipment is nearly all quite prominent to general view.

Tank car shells are presently being painted with one coat of a lead chromate natural oil vehicle type primer and two coats of a natural oil vehicle black, pigmented mainly with carbon black, although some applications of alkyd type paints have been made. A large number of the cars are currently being sand blasted prior to repainting since the last previous paint job on most of them was necessarily allowed to deteriorate through the under coats during the war years due to the shortage of cars and the necessity of keeping them rolling without time out for repainting. Successful experiments in painting the inside of the shells of tank cars with modified vinyl types of pigmented oil resistant coatings have been made. The smooth surface that this type of coating produces facilitates the cleaning and reduces the cleaning labor of cars that must be washed and wiped dry with chamois before loading.

Steel shipping drums are coated with enamels of specified color and applied appearance by the container manufacturer or processor from which they are purchased. Specimen samples of these drum deliveries are picked out periodically at random and placed outside for observation of weather durability. The dry film thickness of the coatings on drums received is also checked periodically and a close inspection check for "skips" and "holidays," hiding quality, runs, "orange peel," and other items of appearance is constantly maintained.

Refinery automotive equipment is recoated when necessary to afford protection and desired appearance. This includes company-owned automobiles, trucks, locomotives, etc., and they are refinished according to the best practices of the original manufacturers by the use of suitable high grade lacquers and enamels after proper surface preparation and application of compatible under coats.

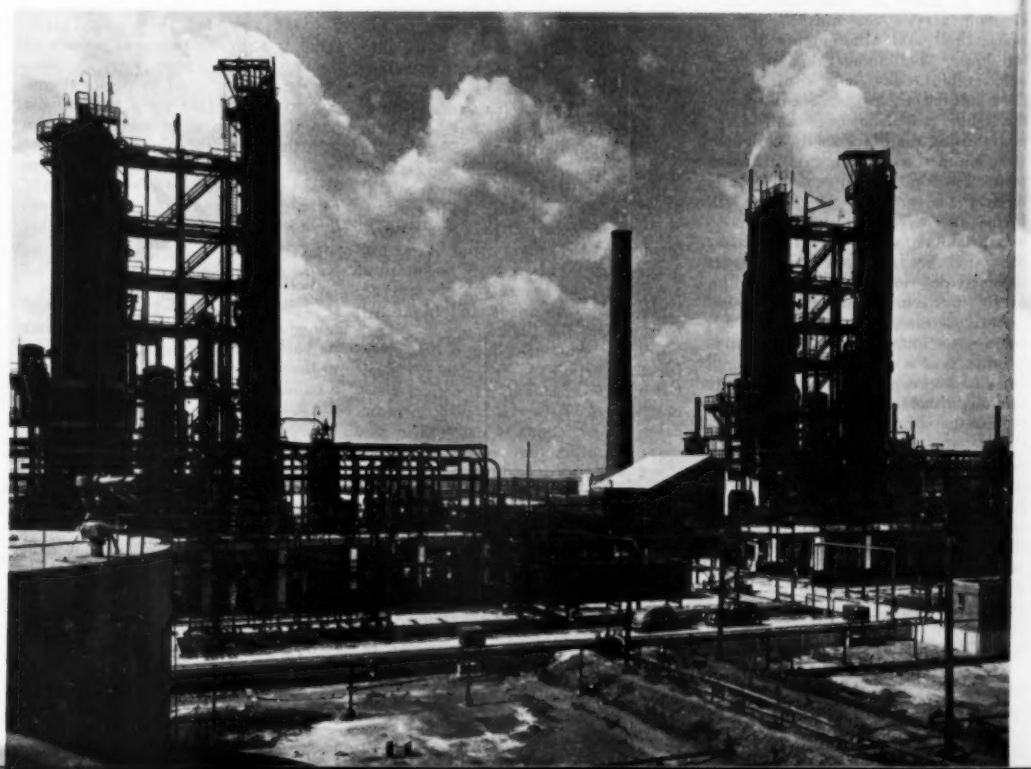
Color Schemes

Finish coats on all equipment at this plant follow definite, well established, standard color schemes. These color schemes, as at most such plants, have been established on a conservative basis. Aluminum and black, combination of the two, or gray, have been found to be more stable and durable and to give a better appearance over a longer period of time, more economically, than other colors.

Machinery such as compressors, engines, and motors, are painted a dark green. Machines in the machine shop have been painted in contrasting colors to bring out and differentiate between critical and non-critical parts.

All fire equipment is painted in brilliant, distinctive colors. Extinguishers

Twin atmospheric-vacuum crude distillation units in Gulf's Port Arthur, Texas, plant. Protective coatings for these units must withstand high temperature in addition to corrosive atmospheric conditions, since the plant is on the Gulf Coast. All fire-fighting equipment of the units is painted bright red.



and the immediate back-ground of each are bright red. Foam lines throughout the plant are painted yellow to indicate the "A" solution lines and green to indicate the "B" solution. Strategically located hose stations are red, as are the fire hydrants.

For interiors of most buildings a standard of black lower portion of walls and aluminum upper portion and ceilings is considered appropriate for longer life of the paint job, both in durability and good appearance. In pump houses, compressor houses, control rooms, etc., a black dado on the walls helps to hide touch marks and any oily smears that may occur while aluminum upper portions of the walls and ceilings afford a lasting finish which at the same time gives good light reflection. Pump bases are black with a six-inch black floor strip extended around the base. Floors are tile red color with black traffic isles.

In the laboratories and some other buildings a "pewter gray" color is used for the dado with a fume-resistant flat white for the upper walls and ceilings.

Aluminum With Band of Black

On the light oil tanks both the shell and the roof are finished with aluminum paint with a band of black of standard height on the bottom of the shell to hide dirt accumulations deposited by splashes from heavy rains. Tanks in crude oil and heavier-than-kerosine service are finished with a black shell and aluminum roof and top upper shell band. Most of these are riveted tanks, and should any dark colored oil leakage occur around the seams, it will not cause as bad appearance on the black shells as if they were painted aluminum. As an extra protection for the portion of tank shells nearest the ground, the bottom six inches is coated with an amorphous wax product of refining operation after the finish coat has dried. This prevents the early deterioration of the paint film on this portion of the shell and consequently deters early corrosion on this bottom section. This rust-preventive product is also applied to underground lines and to some above ground lines and aids considerably in affording protection thereto.

Exceptions are made to use of aluminum paint on some tank roofs and upper shell band where conditions have proven that black paint is economically more suitable for better durability and appearance. These exceptions are made mainly for tanks in chemical or heavy fuel oil service or in areas exposed to corrosive chemical fumes such as strong sulfuric acid, to which the aluminum pigment is not resistant and the black pigments are more inert.

Experimental test work has been conducted in the past with the use of white paints on both roofs and shells of tanks. Although it is a well known fact that interior vapor space temperatures are lower when using white rather than aluminum with resultant lower product evaporation, durability and the appearance of the white falls far short of that obtained with the aluminum finish. Whites must necessarily chalk in order to afford self cleaning of foreign deposits by the washing effect of rains. During the recent war, whites and light grays were necessarily substituted for aluminum and the repainting requirements indicated that aluminum is more desirable for this Gulf Coast climate. Further studies of this in conjunction with evaporation losses may be made.

Exteriors of buildings present somewhat of a color scheme standardization problem since construction materials used cover a fairly wide range of natural state colors, a number of which do not necessarily require painting for protection. A standard scheme of black dado and aluminum or gray upper portion is adhered to, however, more closely than any other since this blends in more closely with the tankage, and the natural color of unpainted galvanized iron, concrete, stucco, transite, etc. A number of the older unpainted buildings are constructed of red brick with red tile roofs and as it becomes necessary to waterproof these buildings, a light gray finish is usually applied. A number of these unwaterproofed brick buildings as well as those of galvanized iron construction are painted with black dado and aluminum upper portion.

Sign painting is a specialized art and a great deal of this is required at the plant. Safety signs prepared in various appropriate color schemes are located throughout the refinery, and huge Gulf orange discs with dark blue lettering are painted on several of the storage tanks along the roads and highways surrounding the plant.

Color schemes are adopted primarily for the purpose of good appearance, but in their adoption, a practical view must be taken since it would, in most cases, be economically unsound to use color pigments that would not withstand certain exposures as well as others merely for the sake of a pleasant appearance.

Conclusion

A comprehensive paint program necessarily is an integral part of refinery maintenance since the primary purpose of painting is to extend the life of equipment by affording protection to exposed surfaces, thereby reducing the amount of repairs and replacements required. However, since the chemistry of paint manufacture and usage is so highly technical, requiring a great deal of study and years of close observation and detailed record keeping in order to intelligently recommend purchase and use of the proper coatings for obtaining the optimum value from the money invested, refinery maintenance as well as operating and purchasing divisions would do well to depend largely on the advice of the plant technical personnel conducting such studies. The differential between the cost of such a program and the actual saving derived therefrom no doubt is obscure, since so many variables enter into a large refinery painting program with new process equipment being built and old equipment being declared obsolete from year to year. However, considering that paint is not a simple commodity that can be purchased and used indiscriminately on the basis of color, appearance, initial material cost, formulation knowledge, laboratory testing, or even initial field test applications, an intelligently planned long term field application and observation program to determine the proper coatings for the various conditions is the correct approach toward maximum protection with minimum cost.

Representatives of the technical departments of reliable paint manufacturing concerns can give much aid in the solution of painting problems at a plant, provided they are fairly familiar with the technical aspects of operation in a general way. This can best be accomplished by personal contact with the plant paint technologist and, if possible, by accompanying him into the plant for observation of the conditions. Since the painting problems at a large refinery are so varied and complex, frequent contact between these technical representatives is highly desirable.

Recommendations Listed

Many other refineries have maintained a technical advisory program on paint and painting practices similar to that at Gulf's Port Arthur plant for a number of years and have found that the benefits derived therefrom greatly overshadow the cost. It is understood that other refining plants have just recently adopted such a program and still others will probably find this plan advisable. For those just entering into such a program and those considering entry, the following points should be borne in mind:

1) The chemistry and mechanics of the proper use of protective coatings at refineries is highly technical, requiring practical as well

Control room interior at Gulf's Port Arthur plant. The steel instrument panel is finished with the same type enamel as that used for automobile painting. This finish is attractive and longer lasting, and easy to clean and polish.

as theoretical knowledge of coating manufacture and usage combined with this same type of knowledge of refinery operations and equipment. This knowledge cannot be accumulated overnight; the protective coating field itself requiring several years of diligent study and practical observation or experience, while the knowledge of refinery operations and equipment also requires years of contact from a technical standpoint. Therefore, technical personnel selected for assignment to this work should either already have this type of background or be given full opportunity to acquire it as they proceed in this capacity.

2) Conclusive results from field test applications, terminating in the issuance of definite recommendations of specific products of the variety of types for particular surfaces, locations, and conditions, require, in most cases, from one to three years since actual "weathering" cannot ordinarily be accelerated except on a laboratory scale and this type of final result only approaches and does not necessarily duplicate actual weathering.

3) Substantial savings should not be expected to show up definitely as such for several years. In fact, costs will, in all probability, increase for two or three years, due to more extensive experimental field testing, and for at least the present and near future, the continued price climb of materials and labor.

4) All products offered cannot possibly be tested since there are hundreds of paint and coating manufacturing firms now in existence, each competing strongly with the others. Therefore, the testing of each of the several types of products of each, say, from three to five prominent, known reliable and responsible firms should first be accomplished.

5) Technical personnel assigned to the coating study, paint manufacturers' representative contact, field test observation and record keeping, etc., work should be on as permanent a basis as possible, and this assignment should not be interrupted until the termination of at least the phase of conclusive test results mentioned in the preceding four points is accomplished.

6) The technical representative is fully occupied with the duties heretofore described and should not be burdened with additional duties of routine administration of the paint department, but at the same time should be given the wholehearted cooperation of paint department personnel as well as all other authoritative company personnel who will seek and follow his technical advice.

* * *

One of five 55,000-barrel tanks, moved by floating them to new locations to clear site for Sun Oil Company's new refinery site at Toledo, Ohio. No. 152 tank at end of first lift, showing dike lock.

Canal Used to Move Five 55,000-Barrel Tanks

MOVING of five 55,000-barrel storage tanks by floating them to new locations recently was accomplished by Catalytic Construction Company for the purpose of clearing the site for Sun Oil Company's $18 million refinery expansion project at Toledo, Ohio.

The method of moving these tanks—floating them in a prepared canal—was chosen because it was both less expensive and less damaging to the tanks than either dismantling them or skidding them. One of the tanks was moved 1510 feet, 187 man hours being required for the task.

The tanks were prepared for floating by emptying their contents, "safing" them, and cleaning them thoroughly. In order to make the tanks water tight up to the level required for floating, all holes in the bottoms were plugged or welded shut and all connections in the bottom rings were closed with blind flanges, pipe caps or welded.

Although the tanks would float in 18 inches of water, dikes were made several times this height in order to provide for clearance in high spots en route and for minor changes in level. When a considerable change of grade was encountered, a lock arrangement was created by building a dike across the canal where there was the greatest change in grade. This dike was broken when the tank was floated to its face, permitting the tank to settle to the lower level. Or if the movement was upgrade, the tank was floated in the lower canal for the maximum distance and the dike built behind it to a height sufficient to hold water necessary to float the tank into position at the higher grade. During the period when these cross dikes are broken, the tank is held firmly in place by cables attached to lugs previously welded on the top of the bottom ring.

It took 24 inches of water to create enough buoyancy to free the tanks from their original foundations. Before a tank was freed, however, two cables were attached to the lugs and connected to bulldozers on either side of the canal, these being used to pull the tank along the canal. One of these bulldozers furnished the pull, the other was used to control the tank as it moved.

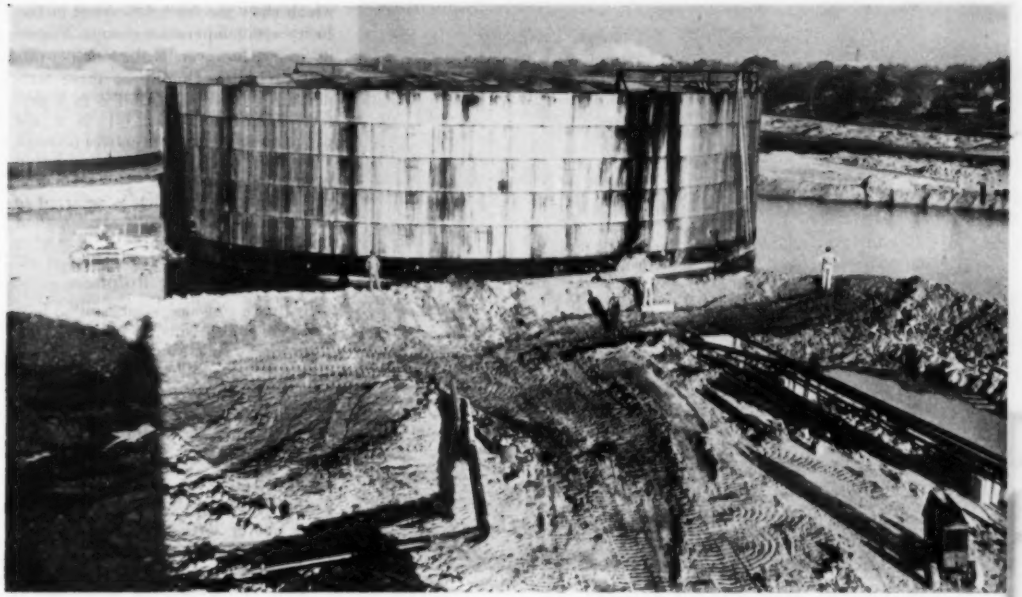
Under calm conditions no great power actually was needed for movement. Several men could have done the job. Sometimes it was necessary to use a third bulldozer in the pond to push or pull the tank over a high spot rather than risk damage to sides of the canal. Under

TABLE 1

Data on Moving of Tanks

Capacity, 55,000 barrels; weight, 200 tons; Height, 30 feet; diameter, 114 feet; pumping capacity, 60,000 gph.

TANK NUMBER	No. 150 (Old 151)	No. 151 (Old 150)	No. 152	No. 153	No. 154
Changes of Grade	603.80' to 606.50' to 602.50'	606.50' to 606.30' to 602.50'	607.70' to 606.30' to 602.50'	606.75' to 606.50' to 602.50'	604.05' to 604.05' to 602.50'
Man Hours	158	187	160	160	125
Moving Time (Hours)	8	8	8	8	8
Depth of Water (Inches Minimum)	18	18	18	18	18
Volume of Water (Millions of Gals.)	2.27	4.25	4.27	4.27	2.24
Pumping Time (Hours)	40	72	72	72	40
Dirt in Dikes (Cubic Yards)	2000	3100	2100	2100	800
Distance Moved (Feet)	920	1510	980	970	230



No. 153 tank floating north on second lift and approaching bend in canal.

windy conditions, only one bulldozer was required on the windward side with another bulldozer in the canal pushing or pulling the tank.

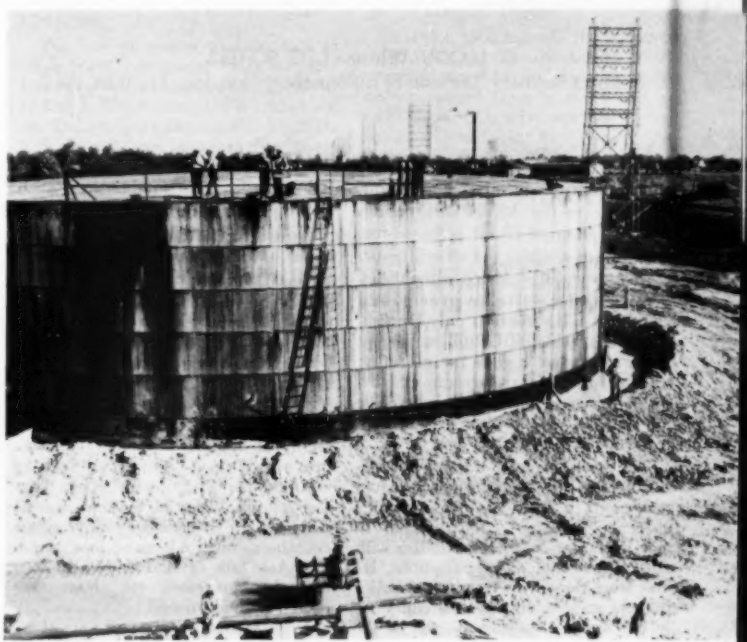
While the tank actually was under way, men were on the inside of the vessel plugging leaks as they occurred with wooden plugs. Also a crew was constantly watching for leaks in the dikes and making repairs.

When the tank reached its now location, it was drawn into a semi-circle formed by five 8 x 8-inch oak posts, set solidly five feet in the ground and protruding some three feet. By means of the three cables these were used for steadying the tank as it was being set on the new foundation, a clay base with a three-inch crown in the center.

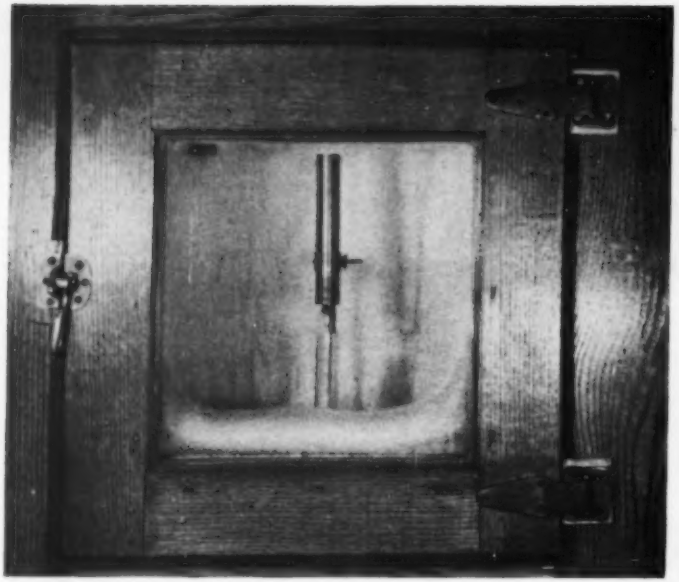
To orient the tank property the procedure was as follows: On a drawing of the tank and the new location, three locating lines were run from fixed visible landmarks in the new tank area to the center of the tank. Where these lines intersected the shell, a target was placed on the shell before the tank was moved. As the tank was about to be set, three transits were set up on the lines between the landmarks and the center of the tank and the tank was shifted around until the targets were sighted on the vertical cross-hairs of the corresponding transits. When the tank was positioned, all lines were held taut before any water was released.

Disposal of such a large volume of water is in itself a major problem, because uncontrolled, it could wash away the new foundations and undermine existing foundations. The water thus should be discharged as slowly as can be allowed. A large ditch will control the water properly outside the pond.

The longest move (1510 feet in eight hours actual moving time) was preceded by 72 hours of pumping with pump capacity of 60,000 gallons per hour. The canal contained about 4¼ million gallons. The tanks were in as good condition on their new foundations as on the old, plus the advantage that all bottom leaks had been plugged. Later these were permanently repaired.



No. 153 tank resting on base. Water nearly drained from canal which was constructed for the floating operations.



Test Apparatus in a Cold Chamber.

Low Temperature Flow Resistance Test for Lubricating Oils

G. L. COULTER and L. C. BORELL
Franklin Refinery, Division of L. Sonneborn Son, Inc., Franklin, Pa.

***AN IMPORTANT** characteristic of motor oils, their fluidity at temperatures near their pour point, has received scant attention. The behavior of oils under such conditions, however, is of real significance, and worthy of the attention of lubricating oil manufacturers. In this short article the authors describe a test procedure useful in establishing the performance of individual oils under low temperature fluid condition.*

ONE of the specifications of a petroleum lubricating oil is pour point. According to the ASTM designation, the pour point of an oil is the lowest temperature at which the oil will pour, or flow, when it is chilled without disturbance under definite prescribed conditions. This test tells only the temperature at which all fluid movement of the oil ceases. It gives no indication how the fluidity characteristics of such an oil change as it approaches this solid point. "Pour point" is therefore a misnomer.

The final judge for winter type lubricating oils is quite often the man who pours it from the container. He observes its actual behavior, but in most instances is neither familiar with nor interested in its specifications. He may store the oil in an unheated building. As needed, he opens a container by punching a hole in the top of the can and pouring it into the crankcase. His or the customer's judgment of such winter oil will be greatly influenced by how freely it flows out of the container at the prevailing low temperatures. If the oil flows freely, he approves of it as he correctly reasons there will be less drag in starting the cold motor. If it is sluggish, he condemns it because of the heavy drag in starting.

The behavior of an oil as it approaches its pour point is therefore a factor of importance. Cold temperature starting characteristics, engine wear and the psychological effect upon the customer when he observes the oil pouring in a sluggish manner from the container are problems of long standing. Any talk of ASTM pour points, dewaxing processes, etc., leaves the customer unimpressed.

High viscosity index oils are those which show the least difference in viscosity with temperature change. Viscosity index, however, is the relative difference in the fluidity at those temperatures at which the oil is in a perfectly fluid state. An oil as it approaches its pour point passes through a critical range where true solution is no longer in effect. The formation of wax particles, which is referred to as "cloud," is a visible evidence of this change.

Two Pour Points

We may consider a lube oil as having two pour points. It has a *natural* pour point, resulting from its crude source and the physical or chemical means employed in its manufacture. It can have a *depressed* pour point, resulting from the addition of a pour-point depressant. Some oils can be produced with natural pour points sufficiently low so that the addition of a depressant is not necessary. Regardless of whether the oil pours by natural means or contains a depressant, there is a temperature range just above its pour point in which its fluidity shows a decided decrease. The behavior of various oils in regards to flow characteristics as they pass through this critical range is distinctly different and is in no manner measured by the ASTM pour point.

The difficulties encountered with fluidity have often been ascribed to pour point reversion or the inability of the depressant to maintain the oil at its depressed value. Considerable research work has been done on this subject. Non-reversibility must be one of the prerequisites of a winter lube oil, but that quality alone does not insure good fluidity.

It is evident that in order to judge the customer's reactions to an oil the refiner must use some other test than the pour point. While such tests as the cloud point, pour and stable pour

points are of great value to the refiner, they do not measure the property of the oil in which he is most interested. A better measure of the expected behavior of a winter oil in the field should be the rate of flow through an orifice under standardized low temperature conditions.

Winter Oils

The scope of this discussion covers only the so-called SAE-10W range. We have chosen this grade for the obvious reason that it is the one with which the motoring public is most intimately concerned, especially in those parts of the country where cold weather is encountered during a part of the year. One of the major specifications of an SAE-10W oil is its calculated viscosity at 0° F. This is determined according to the ASTM viscosity chart with the prescribed limits being 5000 to 10,000 Saybolt seconds. Such determinations have very little meaning as far as the actual viscosity of the oil at 0° F. is concerned. The actual determination of the viscosity at 0° F., using the Saybolt viscosimeter tube, is such a time-consuming operation that it cannot be utilized as a routine test method. The accuracy of such a test is also questionable unless elaborate equipment is employed. The development of a simple, accurate and easily manipulated test method whereby the flow properties of an oil at low temperatures can be studied is a prerequisite.

Description of Flow Resistance Test

The construction of an apparatus for determining the flow resistance of an oil at low temperatures was based upon the principle that its flow time in seconds would be measured through a standardized orifice. (In actual practice a hole is punctured in a sealed can by the service station attendant.) The flow time through this orifice is of such nature that differences in the flow resistant properties of oils can be measured, and can be related to actual field conditions under which it would be used. This apparatus is a simple viscosity tube. Zero degree Fahrenheit is chosen as the test temperature. While temperatures below 0° F. will be encountered in field operations, this temperature is considered to be below the normal average winter conditions in this climate. An oil which flows freely at 0° F. may be considered as having passed a rather severe test. Considerable experimental work has shown that at 0° F. the time of flow through a ¼-inch orifice ranged upward from 20 seconds for a large number of 10W motor oils. These conditions therefore

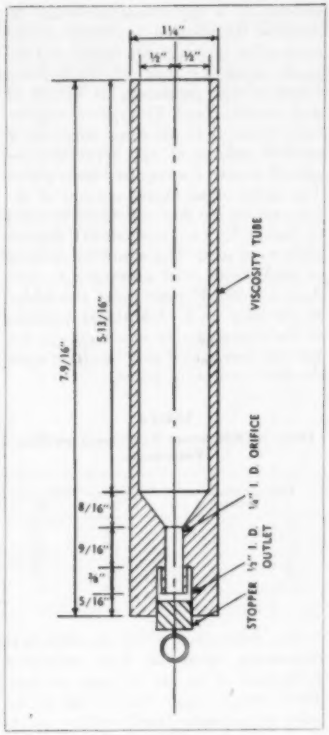


FIGURE 1

seem most suitable for a rapid and accurate test.

The flow resistance viscosity tube is made from a section of brass rod, following those dimensions as given in Figure 1. The accuracy of all tubes are checked using a reference oil. Any tube giving results varying more than 2 percent from the average is discarded.

Method of Test

The oil to be tested is heated to a temperature of 100° F. and 80 cc. of the same poured in the tube. The filled tubes are then placed in the air bath at 0° F. and allowed to remain undisturbed for 24 hours. At the end of the 24-hour period, a 100 cc. graduated cylinder is placed under the tube, the cork removed and the time in seconds necessary for 60 cc. to flow from the tube is measured by means of a stop watch. Duplicate runs on all oils are made. Results which do not check within 2 percent are discarded and the run repeated. The time in seconds is recorded as the flow resistance of the oil at 0° F. The lower values represent better flow characteristics and vice versa.

Influence of Wax Content

The wax content of an oil is known to be related to its suitability as a winter oil. A low wax content oil has a lower ASTM cloud and pour point and shows less tendency toward reversion from its depressed pour point. The influence of added wax on a solvent dewaxed Pennsylvania 200-neutral is noted in Table 1. In this set of experiments both paraffin and microcrystalline wax were added to the neutral and the resultant blends cold tested to —20° F. with the same depressant.

According to Table 1, the flow resistance of an oil rises rapidly with increasing wax content. It is noted that the rise is most rapid after the pour point reaches 15° F. Thus, in order to obtain an oil with a low flow resistance the natural pour point should be below 15° F. It is also to be noted that although the depressed pour points are about the same the flow resistance values differ greatly, showing that the pour point is not a measure of flow characteristics at low temperature.

Influence of Viscosity on Flow Resistance

In order to determine the influence of viscosity on flow resistance, blends covering the SAE-10 viscosity range were prepared from a 200N and an SAE-20 oil. Oils were selected having the same pour point and viscosity index to eliminate the effect of these factors on the blends. The results are given in Table 2.

These data follow the expected pat-

TABLE 2
Influence of Viscosity on Flow Resistance.

Saybolt Viscosity @ 100° F.	Viscosity Index	Pour Point °F.	Depressed Pour Point °F	Flow Resistance
172	105	35	—15	35
186	105	35	—15	45
200	105	35	—15	57
215	105	35	—15	74
232	105	35	—15	93

TABLE 1
Influence of Wax Content.

	PARAFFIN						MICROCRYSTALLINE			
Wax Added, Percent	0	0.5	1.0	2.0	3.0	4.0	1.0	2.0	3.0	4.0
Natural Pour Point, °F.	0	15	20	40	50	60	5	15	20	60
Cloud Point, °F.	14	23	32	48	58	72	12	24	28	67
Depressed Pour Point, °F.	All to —20° F.						All to —20° F.			
Flow Resistance, Seconds	17	22	24	30	48	58	22	27	37	52

tern with the flow resistance increasing as the viscosity increases. Table 2 shows that other factors being equal the viscosity is a very important factor influencing flow resistance. In order to produce a low flow resistant 10W motor oil the viscosity should be kept near the lower limit of the specification range.

Influence of Viscosity Index on Flow Resistance

The effect of this factor was investigated by determining the properties of a large number of oils and selecting oils with nearly the same viscosity and wax content as shown by the cloud point, but varying in viscosity index. Variation in flow resistance thus shows the correlation of these factors. Results are given in Table 3.

TABLE 3
Influence of Viscosity Index on Flow Resistance.

Oil Sample Number	Viscosity Saybolt 210° F.	Cloud °F.	Viscosity Index	Flow Resistance Seconds
1	46.5	18	62	46
2	47	20	97	37
3	47	16	107	30
4	46	18	109	29
5	47	18	110	29
6	47.5	20	121	23

From Table 3, other factors being equal, the flow resistance varies inversely with the viscosity index. Results indicate that in order to obtain a flow resistance below 30 seconds the viscosity index should be over 100.

Amount of Depressant

Those oils whose natural pour points are too high may be reduced by the use of depressants. The apparent role of the depressant is to inhibit the growth of the wax crystals. The amount of a depressant necessary to produce the desired lowering of the pour point is a variable factor and depends upon 1) type of crude from which it was produced, 2) extent of wax removal and 3) type of depressant. There is in all cases, however, a specific volume of any depressant required to give the required pour point. The effect of an excess amount of depressant on the flow resistance is noted in Table 4. Two commercial depressants were used. The minimum amount of each depressant necessary to produce a —20° F. pour point was added to the base stock. Additional amounts of the depressant in increments of 0.1 percent were added and the effect upon the flow resistance noted.

TABLE 4
Effect of Additional Depressant on Flow Resistance.

Additional Depressant Percent	Depressant "A"	Depressant "B"
0.0	59	67
0.1	97	78
0.2	103	106
0.4	122	120
0.5	130	132
0.75	155	161

The deleterious effect of additional depressant upon the flow resistance properties of an oil is quite evident. These results show that as far as the cold temperature fluidity of an oil is concerned the minimum amount of a depressant is the optimum amount. The practice of adding an additional quantity for safety reasons defeats the purpose and increases the flow resistance of an oil.

Flow Resistance of SAE-10W Oils

The flow resistance of a number of lube oils sold through service station outlets were chosen at random. These oils were all purchased in sealed cans and all carried the SAE-10W designation. Table 5 shows the physical properties of these oils arranged in the order of increasing flow resistance.

Following is noted from a correlation of the physical properties of the various samples with the flow resistance values:

1) The flow resistance of a motor oil increases with the viscosity at 100° F. There are some exceptions to this; notably, sample Nos. 8, 19, 20 and 21. The viscosity index of Nos. 8, 19 and 20 is very low, which accounts for their variations. Oil No. 21 has a relatively high viscosity index, but a very high cloud point, which accounts for its high flow resistance although the voscosity at 100° F. is low.

2) The flow resistance generally increases with the cloud point of the oils, with some exceptions. These exceptions either have high viscosities @ 100° F., or low viscosity indices which explains the higher than expected flow resistance for their cloud points.

A low flow resistance depends on a combination of four factors; vis., a low viscosity @ 100° F., a high viscosity index, a low natural pour point and an optimum amount of depressant. From the data given in Table 5, it may be said that in order to obtain a 10W-motor oil with a flow resistance below 30 seconds it should have 1) viscosity @ 100° F. below 190 seconds, 2) viscosity index above 100, 3) natural pour point below 15° F. and 4) a minimum necessary amount of depressant. If a low flow resistance is to be maintained, any shortcoming in one of these properties must be compensated by extra advantage in the others.

TABLE 5
Correlation of Physical Properties with Flow Resistance.

Sample No.	API Gravity	Flash C.O.C. °F.	Saybolt Viscosity at 100° F. Seconds	Viscosity Index	ASTM Cloud	Depressed Pour Point	Pour Resistance
1	31.8	405	170	107	8	—15	22
2	30.5	420	175	101	16	—15	22
3	31.3	435	182	121	20	—20	23
4	31.8	405	182	121	16	—10	25
5	30.5	400	195	110	18	—15	27
6	29.8	410	175	101	26	—20	27
7	30.2	410	182	109	18	—15	29
8	21.6	360	130	72	—12	—25	29
9	30.4	400	200	117	18	—15	29
10	30.7	400	198	107	16	—15	30
11	31.7	430	196.5	108	34	—15	30
12	30.3	420	168	109	34	—10	30
13	30.6	420	186	105	32	—20	31
14	30.2	430	180	111	30	—25	31
15	32.0	420	230	124	22	—10	31
16	31.8	405	182	121	32	—10	35
17	30.5	420	210	97	20	—15	37
18	30.4	470	207	111	32	—15	38
19	25.8	381	161	77	32	—15	40
20	27.9	4 0	195	55	34	—10	42
21	32.0	405	165	95	50	—20	52
22	30.4	430	222	112	42	—15	88
23	31.0	420	205	113	40	—15	117
24	29.8	425	203	113	30	—10	118
25	30.9	425	258	108	48	—10	145

Conclusions and Summary

1) The flow resistance test appears to be a superior method of evaluating the low temperature flow characteristics of a winter type motor oil.

2) A 10W-motor oil should have a maximum natural pour point of 15° F., a maximum Saybolt viscosity @ 100° F. of 190 seconds and a viscosity index above 100 in order to obtain a flow resistance below 30 seconds.

3) A shortcoming in one of the above properties may be compensated by improving the remaining properties.

4) The minimum amount of depressant should be used which is necessary to obtain the required depressed pour point.

CONTINUED here is the authors' effort to put into useful form basic thermodynamic data needed by every technical man who has occasion to make thermodynamic calculations to any appreciable extent. Their announced aim was "to collect all available heat capacity and enthalpy data on important gases and vapors, to evaluate them critically, to make a selection of the most reliable and to present them in the most readily useable forms." Further articles are in preparation.

Dr. Kobe is professor of chemical engineering at the University of Texas and Mr. Long is Celanese Corporation fellow in chemical engineering there.

THERMOCHEMISTRY for the Petrochemical Industry

Part III—Monoolefinic Hydrocarbons, C_2 C_4

KENNETH A. KOBE and ERNEST G. LONG
Department of Chemical Engineering
University of Texas, Austin

TABLE 1
Reported Heat Capacity Data for Monoolefinic Hydrocarbons, C_2 — C_4

Compound	Temp. Range	Method	Workers	Ref.
Ethylene	293 to 464° K.	Calorimetric	Eucken and Parts	6
	0 to 100° C.	Calorimetric	Bruckner	3
	275 to 340° K.	Calorimetric	Haas and Stegeman	8
	270 to 320° K.	Calorimetric	Burcik, Eyster and Yost	4
	0 to 300° C.	"Molecular Beam"	Beeck	2
	300 to 1000° K.	Spectroscopic	Frost	7
	250 to 1500° K.	Spectroscopic	Stull and Mayfield	19
	0 to 1000° C.	Spectroscopic	Justi	9
	−25 to +1250° C.	Spectroscopic	Ellenwood, Kulik and Gay	5
	298 to 1500° K.	Spectroscopic	Thompson	21
	298 to 1500° K.	Spectroscopic	Kilpatrick and Pitzer	11
	273 to 1500° K.	Compilation	API 44	16
Propylene	0 to 300° C.	"Molecular Beam"	Beeck	2
	270 to 510° K.	Supersonic	Telfair	20
	272 to 367° K.	Calorimetric	Kistiakowsky and Rice	12
	272 to 367° K.	Spectroscopic	Kistiakowsky and Rice	12
	250 to 1500° K.	Spectroscopic	Stull and Mayfield	19
	298 to 1000° K.	Spectroscopic	Kemitz	10
	298 to 1500° K.	Spectroscopic	Kilpatrick and Pitzer	11
	273 to 1500° K.	Compilation	API 44	16
1-Butene	−30 to +90° C.	Calorimetric	Wacker, Cheney and Scott	22
	250 to 1500° K.	Spectroscopic	Stull and Mayfield	19
	298 to 1500° K.	Spectroscopic	Aston, Szasz, Woolley and Brickwedde	1
	298 to 1500° K.	Spectroscopic	Kilpatrick and Pitzer	11
	273 to 1500° K.	Compilation	API 44	16
cis-2-Butene	245 to 300° K.	Calorimetric	Scott, Ferguson and Brickwedde	17
	298 to 371° K.	Calorimetric	Kistiakowsky and Rice	13
	300 to 1500° K.	Spectroscopic	Scott, Ferguson and Brickwedde	17
	298 to 1500° K.	Spectroscopic	Aston, Szasz, Woolley and Brickwedde	1
	298 to 1500° K.	Spectroscopic	Kilpatrick and Pitzer	11
	273 to 1500° K.	Compilation	API 44	16
trans-2-Butene	298 to 371° K.	Calorimetric	Kistiakowsky and Rice	13
	298 to 1500° K.	Spectroscopic	Aston, Szasz, Woolley and Brickwedde	1
	298 to 1500° K.	Spectroscopic	Kilpatrick and Pitzer	11
	273 to 1500° K.	Compilation	API 44	16
iso-Butene	−35 to +80° C.	Calorimetric	Scott and Mellors	18
	298 to 1500° K.	Spectroscopic	Kilpatrick and Pitzer	11
	273 to 1500° K.	Compilation	API 44	16

In the first article[14] of this series the method of selection and usefulness of the data presented are discussed in detail. The second article[15] contains the best available thermodynamic data on the lower members of the paraffinic hydrocarbon series. In logical sequence, this article contains the recommended thermodynamic data for the monoolefinic hydrocarbons ethylene, propylene, 1-butene, cis-2-butene, trans-2-butene and iso-butene.

As in the previous article, the *American Petroleum Institute Research Project 44*[16] has been of considerable help. For each of the compounds discussed here, the API 44 report has accepted without alterations the spectroscopic calculations of Kilpatrick and Pitzer.[11] The data of Kilpatrick and Pitzer are in good agreement with careful calorimetric determinations. The tabulated heat capacities values of the API 44 report have been used without any basic changes.

Table 1 lists the various sources of heat capacity data for the gaseous compounds in this article. The standard heats of formation and combustion and the standard free energies of formation from the API 44 report are presented in Table 2.

The heat capacity data are tabulated in convenient units and at convenient temperatures on all four temperature scales in Tables 3, 4, 5 and 6. These data are graphically presented in Figure 1 (see next page) with two temperature scales.

As before[15] the enthalpy data of the API 44 report were not suitable for use here. The enthalpies in Tables 7, 8, 9 and 10 are relative to 0° C. (32° F., 273° K., 492° R.) and were obtained by careful integration of the heat capacity-temperature relations of Tables 3, 4, 5 and 6. The enthalpy data are conveniently plotted on a double logarithmic graph in Figure 2. (See next page.)

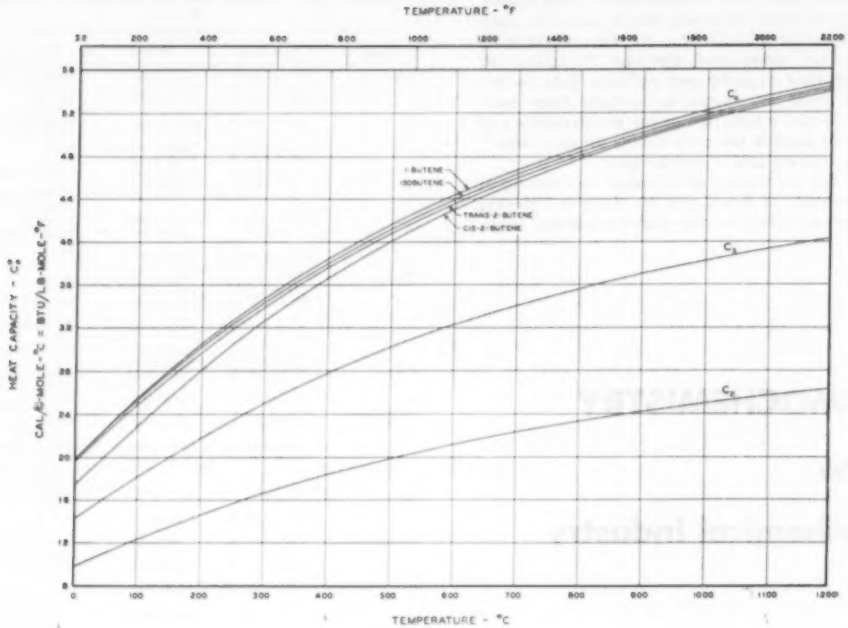
The mean heat capacities of Tables 11 and 12 were calculated from the enthalpy data of Tables 7 and 9, respectively. Although the mean heat capacities and enthalpies are equivalent, the brevity of the former and their utility in interpolation warrants their inclusion.

The equations of Table 13 will prove satisfactory for almost all engineering calculations.

The maximum error produced in using these equations between 0 and 1200° C. is 0.83 percent with cis-2-butene, 0.73 percent with propylene, 0.57 percent with trans-2-butene, 0.54 percent with ethylene, 0.38 percent with 1-butene and 0.30 percent with iso-butene. The average error varies from 0.1 to 0.2 percent.

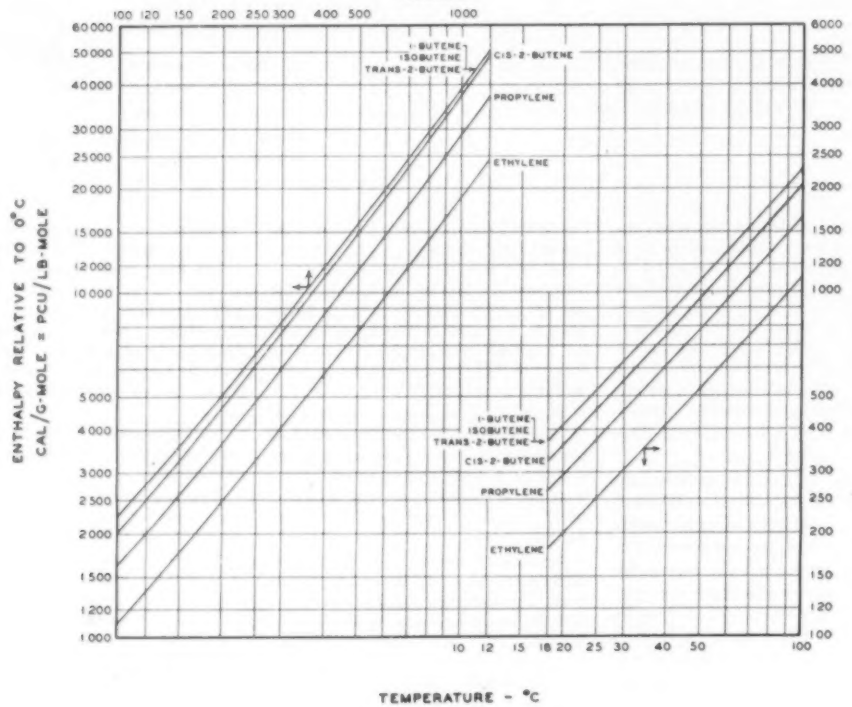
The relative amounts of cis and trans-2- butene in an equilibrium mix-

FIGURE 1



HEAT CAPACITY OF MONO-OLEFINS

FIGURE 2



ture may be calculated by means of the free energy data as stated in the first article.[14] The percentage cis-2-butene in such a mixture increases rapidly from 22.7 percent at 300° K. to 38.7 percent at 700° K., begins to level off and is 40.9 percent at 1000° K. and 41.9 percent at 1500° K. These results were calculated from the free energy data of the *American Petroleum Institute Research Project 44.*

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TABLE 2

Free Energy of Formation, Heat of Formation and Heat of Combustion of Monoolefinic Hydrocarbons, C_2 — C_4, at 25° C.[1]

	Molecular Weight	ΔG°_f cal./g-mole	ΔH°_f cal./g-mole	$-\Delta H^\circ_c$ cal./g-mole	
				H_2O (liq.), CO_2(gas)	H_2O (gas), CO_2(gas)
Ethylene	28.052	16,282	12,496	337,234	316,195
Propylene	42.078	14,990	4,879	491,987	460,426
1-Butene	56.104	17,217	280	649,757	607,679
iso-Butene	56.104	14,582	−3,343	646,134	604,056
cis-2-Butene	56.104	16,046	−1,362	648,115	606,037
trans-2-Butene	56.104	15,315	−2,405	647,072	604,994

[1] $-\Delta H^\circ_c$ represents the heat evolved at 25° C. and constant pressure in the combustion of the gaseous hydrocarbon in gaseous oxygen to form the products indicated with all the reactants and products in their appropriate standard reference states.

ΔH°_f and ΔG°_f represent the changes in the heat content (enthalpy) and free energy, respectively, for the formation of the gaseous hydrocarbons from the elements, with all the reactants and products in their appropriate standard reference states.

TABLE 3

Heat Capacities of Monoolefinic Hydrocarbons, C_2 — C_4 cal./g-mole · °C.

°C.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
0	9.78	14.32	19.87	19.93	17.51	19.74
18	10.22	15.01	20.94	20.91	18.47	20.63
25	10.41	15.27	21.35	21.30	18.86	20.99
100	12.29	18.11	25.53	25.22	22.91	24.71
200	14.58	21.71	30.53	30.04	28.08	29.47
300	16.61	24.92	34.79	34.27	32.67	33.75
400	18.33	27.69	38.42	37.92	36.64	37.47
500	19.82	30.09	41.56	41.08	40.04	40.70
600	21.13	32.19	44.28	43.85	42.98	43.51
700	22.29	34.01	46.65	46.26	45.53	45.97
800	23.28	35.60	48.72	48.36	47.74	48.13
900	24.16	36.98	50.51	50.19	49.66	49.98
1000	24.95	38.19	52.07	51.78	51.33	51.60
1100	25.63	39.25	53.45	53.17	52.78	53.01
1200	26.22	40.17	54.64	54.38	54.03	54.25

TABLE 4

Heat Capacities of Monoolefinic Hydrocarbons, C_2 — C_4 cal./g-mole · °K.

°K.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
273	9.78	14.32	19.87	19.93	17.51	19.74
291	10.22	15.01	20.94	20.91	18.47	20.63
298	10.41	15.27	21.35	21.30	18.86	20.99
300	10.45	15.34	21.45	21.39	18.96	21.08
400	12.90	19.10	26.94	26.57	24.33	26.02
500	15.16	22.62	31.75	31.24	29.39	30.68
600	17.10	25.70	35.82	35.30	33.80	34.80
700	18.76	28.37	39.31	38.81	37.60	38.38
800	20.20	30.68	42.33	41.86	40.87	41.50
900	21.46	32.70	44.95	44.53	43.70	44.20
1000	22.57	34.46	47.24	46.85	46.15	46.58
1100	23.54	35.99	49.23	48.88	48.28	48.65
1200	24.39	37.32	50.96	50.63	50.13	50.44
1300	25.14	38.49	52.47	52.17	51.74	52.00
1400	25.79	39.51	53.79	53.51	53.15	53.36
1500	26.36	40.39	54.93	54.68	54.35	54.53

TABLE 5

Heat Capacities of Monoolefinic Hydrocarbons, C_2 — C_4 Btu/lb.-mole · °F.

°F.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
32	9.78	14.32	19.87	19.93	17.51	19.74
60	10.16	14.91	20.77	20.77	18.34	20.51
77	10.41	15.27	21.35	21.30	18.86	20.99
100	10.71	15.78	22.06	21.96	19.54	21.61
200	12.10	17.85	25.16	24.87	22.53	24.37
300	13.41	19.89	28.03	27.63	25.47	27.06
400	14.67	21.85	30.71	30.22	28.28	29.66
500	15.83	23.67	33.15	32.63	30.90	32.09
600	16.88	25.36	35.37	34.85	33.31	34.34
700	17.86	26.91	37.40	36.89	35.53	36.42
800	18.74	28.35	39.28	38.78	37.57	38.35
900	19.57	29.67	41.01	40.52	39.45	40.14
1000	20.33	30.90	42.60	42.15	41.17	41.79
1100	21.04	32.04	44.08	43.65	42.77	43.31
1200	21.71	33.09	45.45	45.04	44.24	44.72
1300	22.32	34.07	46.72	46.33	45.60	46.04
1400	22.89	34.97	47.90	47.53	46.86	47.27
1500	23.42	35.81	48.98	48.63	48.03	48.40
1600	23.91	36.58	49.99	49.65	49.10	49.44
1700	24.37	37.30	50.93	50.59	50.10	50.40
1800	24.80	37.96	51.79	51.48	51.02	51.30
1900	25.20	38.58	52.59	52.29	51.87	52.13
2000	25.57	39.16	53.33	53.05	52.65	52.89
2100	25.91	39.69	54.02	53.75	53.38	53.60
2200	26.22	40.18	54.66	54.39	54.05	54.26

TABLE 6

Heat Capacities of Monoolefinic Hydrocarbons, C_2 — C_4 Btu/lb.-mole · °R.

°R.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
492	9.78	14.32	19.87	19.93	17.51	19.74
500	9.88	14.48	20.14	20.17	17.75	19.96
520	10.16	14.91	20.77	20.77	18.34	20.51
537	10.41	15.27	21.35	21.30	18.86	20.99
600	11.25	16.50	23.36	23.14	20.74	22.72
700	12.61	18.68	26.33	25.99	23.72	25.46
800	13.92	20.99	29.17	28.69	26.52	28.12
900	15.13	22.60	31.75	31.21	29.35	30.65
1000	16.26	24.36	34.09	33.54	31.89	33.01
1100	17.28	26.00	36.18	35.69	34.22	35.19
1200	18.22	27.51	38.20	37.66	36.37	37.21
1300	19.08	28.89	39.99	39.49	38.34	39.08
1400	19.86	30.18	41.70	41.19	40.15	40.82
1500	20.60	31.37	43.21	42.76	41.82	42.41
1600	21.30	32.48	44.68	44.22	43.37	43.89
1700	21.95	33.49	45.99	45.57	44.80	45.26
1800	22.54	34.44	47.24	46.82	46.12	46.54
1900	23.09	35.32	48.35	47.98	47.34	47.73
2000	23.64	36.12	49.43	49.05	48.47	48.83
2100	24.11	36.88	50.35	50.03	49.51	49.83
2200	24.54	37.57	51.31	50.95	50.48	50.77
2300	24.97	38.21	52.14	51.81	51.37	51.64
2400	25.35	38.82	52.93	52.60	52.19	52.44
2500	25.70	39.38	53.65	53.34	52.95	53.18
2600	26.04	39.89	54.32	54.01	53.65	53.87

TABLE 7

Enthalpies of Monoolefinic Hydrocarbons, C_2 — C_4 cal./g-mole

°C.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
0	0.0	0.0	0.0	0.0	0.0	0.0
18	180.0	264.0	367.3	367.6	323.8	363.3
25	252	370	515	515	453	508
100	1097	1623	2272	2263	2011	2215
200	2443	3617	5083	5029	4570	4931
300	4006	5945	8353	8250	7622	8084
400	5753	8579	12020	11860	11000	11650
500	7667	11470	16020	15810	14930	15560
600	9714	14580	20310	20050	19080	19790
700	11880	17900	24860	24550	23500	24260
800	14170	21380	29630	29290	28170	28970
900	16540	25020	34600	34230	33040	33890
1000	19000	28780	39720	39340	38100	38950
1100	21530	32650	45000	44590	43310	44190
1200	24120	36620	50410	49970	48660	49560

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End of Part III. Part IV will appear in an early issue.

Parts I and II of this series appeared, respectively, in the December and January issues.

TABLE 8
Enthalpies of Monoolefinic Hydrocarbons, C_2 — C_4
cal./g-mole

°K.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
273	0.0	0.0	0.0	0.0	0.0	0.0
291	180.0	264	367.3	367.6	323.8	363.3
298	252	370	515	515	453	508
300	269	398	553	555	483	541
400	1436	2123	2977	2956	2646	2895
500	2842	4200	5919	5848	5341	5735
600	4457	6625	9300	9184	8512	9003
700	6252	9333	13060	12880	12080	12670
800	8205	12280	17150	16920	16010	16660
900	10290	15450	21510	21230	20240	20950
1000	12490	18820	26120	25800	24730	25500
1100	14800	22340	30950	29600	29460	30270
1200	17290	26010	35960	35580	34380	35230
1300	19680	29800	41130	40730	39480	40350
1400	22220	33700	46440	45020	44730	45620
1500	24830	37700	51880	51430	50120	51020

TABLE 9
Enthalpies of Monoolefinic Hydrocarbons, C_2 — C_4
Btu/lb.-mole

°F.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
32	0.0	0.0	0.0	0.0	0.0	0.0
80	275.0	409.2	569.3	569.8	502.0	563.6
77	454	666	927	927	816	915
100	697	1022	1426	1425	1257	1404
200	1829	2702	3771	3770	3344	3692
300	3105	4591	6446	6390	5745	6267
400	4511	6674	9385	9285	8444	9106
500	6037	8950	12580	12430	11410	12190
600	7672	11400	16000	15810	14630	15500
700	9408	14010	19640	19390	18070	19040
800	11240	16780	23480	23170	21720	22790
900	13160	19680	27490	27140	25570	26710
1000	15160	22700	31680	31270	29610	30900
1100	17220	25850	36010	35550	33800	35090
1200	19360	29110	40480	39950	38150	39460
1300	21550	32470	45090	44540	42640	44010
1400	23820	35930	49820	49240	47260	48690
1500	26150	39450	54650	54070	52000	53460
1600	28500	43070	59630	59000	56880	58400
1700	30920	46770	64610	64000	61820	63390
1800	33390	50560	69790	69100	66870	68440
1900	35880	54380	75010	74320	72030	73690
2000	38410	58260	80280	79590	77240	78880
2100	40990	62210	85670	84920	82570	84210
2200	43600	66210	91110	90310	87960	89590

TABLE 10
Enthalpies of Monoolefinic Hydrocarbons, C_2 — C_4
Btu/lb.-mole

°R.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
492	0.0	0.0	0.0	0.0	0.0	0.0
500	78.6	115.2	160.1	160.4	141.0	158.8
520	279.0	409.2	569.3	569.8	502.0	563.6
537	454	666	927	927	816	915
600	1140	1671	2331	2364	2118	2331
700	2339	3440	4831	4819	4341	4690
800	3667	5413	7610	7550	6857	7373
900	5121	7569	10650	10550	9660	10310
1000	6691	9917	13940	13790	12720	13488
1100	8361	12430	17460	17250	16030	16892
1200	10146	15110	21170	20910	19550	20520
1300	12070	17930	25080	24770	23280	24340
1400	13960	20880	29180	28780	27210	28320
1500	15980	23950	33410	33100	31340	32480
1600	18050	27150	37870	37330	35560	36890
1700	20230	30450	42420	41820	39960	41280
1800	22460	33880	47060	46450	44500	45870
1900	24750	37340	51750	51200	49170	50590
2000	27090	40880	56660	56070	53970	55430
2100	29470	44510	61650	61030	58870	60390
2200	31900	48200	66750	66070	63850	65410
2300	34380	52050	71980	71210	68940	70500
2400	36890	55930	77160	76460	74120	75710
2500	39440	59840	82440	81760	79390	81000
2600	42030	63820	87870	87120	84740	86350

TABLE 11
Mean Heat Capacities of Monoolefinic Hydrocarbons, C_2 — C_4
cal./g-mole · °C.

°C.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
0	9.78	14.32	19.87	19.93	17.51	19.74
18	10.00	14.67	20.41	20.42	17.99	20.18
25	10.09	14.80	20.60	20.60	18.13	20.33
100	10.97	16.23	22.72	22.63	20.11	22.15
200	12.22	18.09	25.42	25.15	22.88	24.66
300	13.35	19.82	27.84	27.50	25.41	26.95
400	14.38	21.45	30.05	29.65	27.73	29.13
500	15.33	22.94	32.04	31.62	29.86	31.12
600	16.19	24.30	33.85	33.42	31.80	32.97
700	16.97	25.57	35.51	35.07	33.57	34.66
800	17.71	26.73	37.04	36.61	35.21	36.21
900	18.38	27.80	38.44	38.03	36.71	37.66
1000	19.00	28.78	39.72	39.34	38.10	38.96
1100	19.57	29.68	40.91	40.54	39.37	40.17
1200	20.10	30.52	42.01	41.64	40.55	41.30

TABLE 12
Mean Heat Capacities of Monoolefinic Hydrocarbons, C_2 — C_4
Btu/lb.-mole · °F.

°F.	Ethylene	Propylene	1-Butene	iso-Butene	cis-2-Butene	trans-2-Butene
32	9.78	14.32	19.87	19.93	17.51	19.74
60	9.97	14.61	20.32	20.36	17.89	20.11
77	10.09	14.80	20.60	20.60	18.13	20.33
100	10.25	15.03	20.97	20.96	18.49	20.65
200	10.89	16.08	22.45	22.44	19.90	21.98
300	11.59	17.13	24.05	23.84	21.44	23.38
400	12.26	18.14	25.50	25.23	22.95	24.74
500	12.90	19.12	26.88	26.56	24.38	26.05
600	13.51	20.07	28.17	27.83	25.76	27.29
700	14.08	20.97	29.40	29.03	27.05	28.50
800	14.64	21.72	30.57	30.17	28.28	29.67
900	15.16	22.67	31.67	31.27	29.46	30.77
1000	15.66	23.45	32.72	32.30	30.59	31.82
1100	16.12	24.20	33.72	33.29	31.65	32.83
1200	16.58	24.92	34.66	34.22	32.66	33.78
1300	17.00	25.61	35.56	35.13	33.63	34.71
1400	17.41	26.26	36.42	35.99	34.55	35.59
1500	17.81	26.87	37.23	36.83	35.42	36.42
1600	18.18	27.47	38.03	37.63	36.28	37.24
1700	18.54	28.04	38.78	38.37	37.06	38.00
1800	18.89	28.60	39.47	39.08	37.82	38.71
1900	19.21	29.11	40.16	39.79	38.56	39.40
2000	19.52	29.60	40.89	40.44	39.25	40.08
2100	19.82	30.08	41.43	41.06	39.93	40.72
2200	20.11	30.54	42.02	41.66	40.57	41.32

TABLE 13
Heat Capacity Equations[1] of Monoolefinic C_2 — C_4
cal./g-mole · °C. or °K.
Btu/lb.-mole · °F. or °R.

$$C^\circ_p = a + b(t) + c(t^2) + d(t^3)$$

		a	b · 10^2	c · 10^5	d · 10^9	ERROR Max., Percent	ERROR Avg., Percent
Ethylene	°C.	9.740	2.741	—1.647	4.220	0.49	0.15
	°K.	0.944	3.735	—1.993	4.220	0.54	0.13
	°F.	9.259	1.973	—0.5153	0.7236		
	°R.	0.944	2.075	—0.6151	0.7236		
Propylene	°C.	14.240	4.233	—2.430	5.880	0.66	0.18
	°K.	0.753	5.691	—2.910	5.880	0.73	0.17
	°F.	13.498	2.982	—0.7591	1.008		
	°R.	0.753	3.162	—0.89981	1.008		
1-Butene	°C.	19.810	6.128	—4.127	12.07	0.38	0.19
	°K.	—0.240	8.650	—5.110	12.07	0.25	0.18
	°F.	18.737	4.679	—1.292	2.070		
	°R.	—0.240	4.806	—1.577	2.070		
iso-Butene	°C.	19.873	5.708	—3.324	8.020	0.30	0.10
	°K.	1.650	7.702	—3.981	8.020	0.11	0.06
	°F.	18.870	4.029	—1.039	1.375		
	°R.	1.650	4.279	—1.229	1.373		
cis-2-Butene	°C.	17.400	6.030	—3.428	7.890	0.83	0.19
	°K.	—1.778	8.078	—4.074	7.890	0.78	0.14
	°F.	16.342	4.199	—1.070	1.353		
	°R.	—1.778	4.488	—1.257	1.353		
trans-2-Butene	°C.	19.640	5.498	—2.906	6.070	0.57	0.17
	°K.	2.340	7.220	—3.403	6.070	0.34	0.12
	°F.	18.673	3.713	—0.9060	1.041		
	°R.	2.340	4.011	—1.050	1.041		

[1] **Temperature Ranges:** 0—1200° C.; 273—1500° K.; 32—2200° F.; 492—2600° R.

ETHYLENE GLYCOL
By Air Oxidation of Ethylene

PETER W. SHERWOOD
Koppers Company, Inc., Pittsburgh

"Anti-catalysts" development promises higher efficiency over present manufacturing processes

ETHYLENE glycol is today one of the largest-scale and fastest-growing organic chemicals. Its 1947 production in the United States was 210 million pounds. Since that time, two new companies have entered production. One plant has been constructed by Jefferson Chemical Company near Port Arthur, Texas; another by Wyandotte Chemicals Corporation at Wyandotte, Mich. The added capacity of these two plants, together with recently expanded facilities by Dow Chemical Company and Carbide and Carbon Chemicals Corporation is expected to boost the United States production of ethylene glycol to more than 315 million pounds per year.[1]

***DIRECT AIR** oxidation of ethylene is an attractive process for the manufacture of ethylene oxide and ethylene glycol. By today's industrial methods, yields of only 50-55 percent are possible, but the development of "anti-catalysts" promises higher efficiency. All installations of this process employ a silver catalyst which effects a highly specific course of oxidation. Carbon dioxide and water are, in effect, the only by-products. The amount of heat evolved during the reaction is especially high for inefficient conversion conditions and a difficult design problem is created by the need for adequate heat removal. First cost of ethylene oxidation plants is comparatively high, but the cost of the oxidizing agent is negligible. The choice between direct oxidation and chlorohydrination of ethylene for the manufacture of glycol depends on a variety of factors which are discussed in this article.*

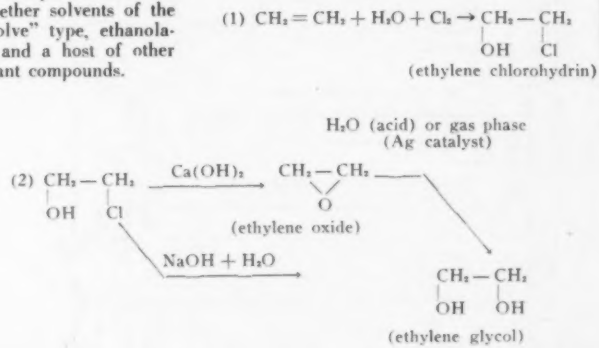
The field of usefulness for ethylene glycol, and its close relative ethylene oxide, is immense. Seventy-seven percent of the 1944 production of glycol went into the production of antifreezes. Yet, glycol accounted for only 23 percent of the total antifreeze market. Huge additional uses are found in the manufacture of dinitro glycol which is employed to reduce the danger due to freezing of dynamite. The reaction between ethylene oxide and hydrocyanic acid is a major source of acrylonitrile which finds a great outlet as copolymer in Buna-N synthetic rubber and a variety of synthetic fibers. Ethylene oxide can be reacted with alkyl phenols to form a series of important detergents. Further uses include the production of glycol ether solvents of the "cellosolve" type, ethanolamines, and a host of other important compounds.

Of the three processes used in the United States for the manufacture of ethylene glycol, two—based on ethylene—are of immediate interest to the petroleum industry. The third, practiced by DuPont at Belle, W. Va., is based on the formation of glycolic acid by the high-pressure, high-temperature reaction between formaldehyde, carbon monoxide, and hydrogen. Glycolic acid is then esterified and reduced to ethylene glycol.

The most common process employed in this country for the synthesis of ethylene glycol involves the chlorohydrination of ethylene followed by hydrolysis. This classical method was originally employed by Carbide and Carbon Chemicals Corporation in the first American ethylene glycol plant at South Charleston, W. Va., in 1922. It is still the basis for glycol production by Dow Chemical Company, Wyandotte Chemicals Corporation, Jefferson Chemical Company, and a number of other manufacturers. The synthesis is carried out by the following series of reactions:

The process is carried out with an over-all yield of 70-80 percent based on both ethylene and chlorine. The most important byproduct is ethylene dichloride.

The direct oxidation of ethylene by air seems, on the surface, like the most



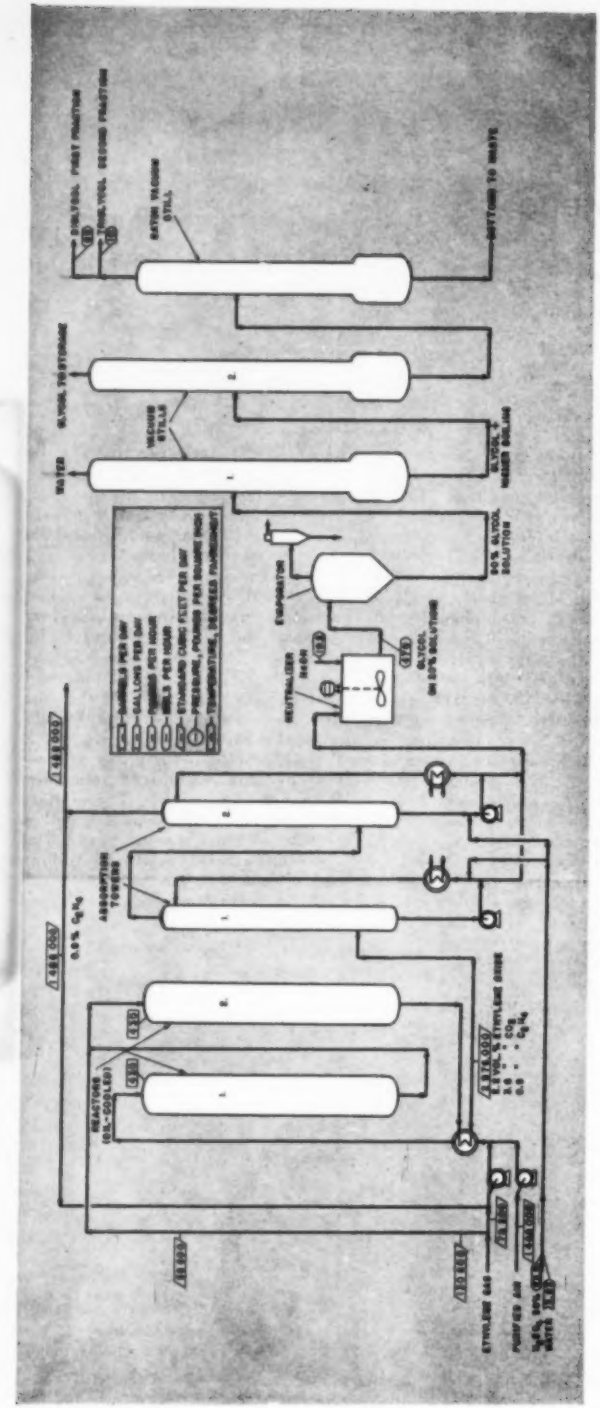


FIGURE 1
Flow Sheet for Manufacture of Glycol by Direct Oxidation of Ethylene (Zweckel Plant)

attractive way of manufacturing ethylene oxide and ethylene glycol. No chlorine is required. Instead, the oxidizing medium is obtained at negligible cost.

As a matter of fact, the partial oxidation of ethylene by molecular oxygen did not become known until 1931. Earlier work had indicated that the air oxidation of ethylene could not stop short of carbon dioxide and water, with the possible formation of small amounts of formaldehyde. Schutzenberger[2] reported this observation for the non-catalytic oxidation of ethylene at 400° C. as early as 1879. His findings were confirmed by Blair and Wheeler in 1922.[3]

In 1928, Reyerson and Swearingen[4] reported that ethylene could be air-oxidized at temperatures as low as 100° C. by the use of metallized silica gel catalysts, among them silver-coated silica gel. They identified only carbon dioxide and water in the products of reaction. Much later, after Lefort had definitely established the usefulness of silver catalysts for the air oxidation of ethylene to ethylene oxide, Reyerson and Oppenheimer[5] repeated this work and found that very small amounts of ethylene oxide were indeed formed over silver-covered silica gels and that the yield could be increased by the admixture of appreciable amounts of steam.

In 1931, Lenher[6] reported for the first time the production of ethylene oxide by the air oxidation of ethylene. Lenher's oxidation was non-catalytic. In fact, it had to be carried out in wide tubes in order to avoid an undesirable wall effect. The process was characterized by exceedingly low conversion per pass but a total ethylene oxide yield as high as 20 percent could be obtained. By-products included CO_2, water, formaldehyde, formic acid, dioxymethyl peroxide, and hydrogen peroxide. The process matured into U. S. Patent 1,995,991 (to E. I. duPont de Nemours and Company). The low conversion per pass and unsatisfactory yields defeated the commercial usefulness of Lenher's process.

The applicability of a catalyst to ethylene oxide production by air oxidation was widely denied. As late as 1932, Marek and Hahn wrote of this reaction:[7]

> "The direct applicability of catalysts to such an oxidation reaction for the purpose of increasing rate of reaction or increasing conversion to ethylene oxide is highly questionable in the light of present knowledge regarding chain reactions."

In March, 1931, T. E. Lefort obtained a French patent[8] for the production of ethylene oxide by the air oxidation of ethylene at moderate temperatures and pressures over a number of catalysts, including pure and supported arsenic, antimony, bismuth, lead, gold, nickel, tin, iron, silver, and mixtures of these metals. Actually, silver was found to be the only commercially useful catalyst and this has been employed by a number of companies including Carbide and Carbon Chemicals Company (at South Charleston, W. Va.), United States Industrial Chemicals, Inc. (at Baltimore, Md.), and a number of foreign firms. The United States reissue patent (20,370) covering this process was declared invalid on grounds of operational details by a 1942 decision of the United States Supreme Court. A second reissue patent (U. S. Re. 22,241) attempting to protect certain specific aspects of the Lefort process was held invalid in a 1946 declaratory judgment by the U. S. District Court of New York.

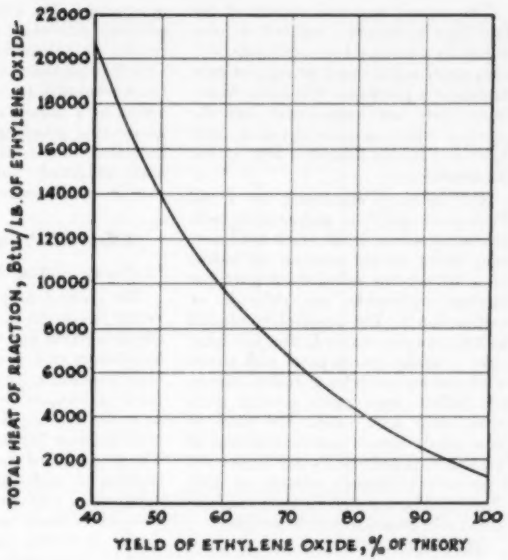


FIGURE 2
Effect of Conversion Efficiency on Heat of Reaction.

Description of the Process

As far as is known, silver is the only catalyst which is employed by any of the companies manufacturing ethylene oxide and ethylene glycol by air oxidation. Various companies have different methods of preparing the catalyst. This aspect will be discussed in a later section.

It is customary to mix ethylene with a large excess of air, enough to maintain the concentration below the explosive limits. The gas mixture is preheated in exchange with the product and is introduced into the catalytic converter in which the temperature is carefully controlled at the optimum temperature. (This varies between 200-300° C. depending on the nature and age of the catalyst). The ethylene conversion per pass is about 40-45 percent. Part of the effluent ethylene must be bled from the system. Thus, while the catalyst efficiency is about 55 percent, a yield, based on ethylene, of only about 50 percent is realized. *There are, in effect, no by-products of the reaction other than carbon dioxide and water.* The only organic impurity formed is acetaldehyde.‡ Its production is so small, however, that the final concentrated glycol contains less than 0.2 percent aldehydes.

The ethylene oxide is removed from the products of reaction by absorption in water under pressure or in acid solution (in which case ethylene oxide is hydrolized to glycol). The aqueous solution is evaporated (after neutralization, if necessary) to 90 percent glycol concentration. The glycol is then purified by fractionation under vacuum. In the course of this process, some diglycols and triglycols are formed as recoverable by-products.

A part of the scrubbed gases is recycled. The remainder is bled from the system.

Figure 1 is a flow sheet of this process as modified by I. G. Farbenindustrie for use at the Zweckel plant near Gladbeck, Germany.

Preparation of the Catalyst

The Lefort patents are quite vague on the manner of catalyst preparation. From all indications, silver in pure form or on a support is by far the preferred catalyst. The use of unsupported silver does not bring any appreciable technical advantages, however, and is uneconomical. A carrier is employed in all cases.

The nature of the support is very significant. Reyerson and Oppenheimer's work[5] indicates clearly that silica gel is not a satisfactory carrier. In the absence of steam, yields of only 1-2 percent can be obtained. This efficiency can be doubled by the use of 50 volume percent steam.

Tests by United States Industrial Chemicals, Inc.[9] further substantiate the important effect of the catalyst carrier. A series of catalysts were prepared by evaporating a slurry of silver oxide and carrier to dryness. The product was reduced by hydrogen at a temperature below 100° C. and tested for ethylene oxide production under controlled conditions. Comparative results obtained are shown in Table 1.

TABLE 1

Support	Single Pass Conversion, Percent	Ethylene Oxide Yield, Percent	Temp. °C.
Pumice	14.0	51.3	212
Glass	8.8	63.9	200
Alundum	27.1	30.6	207
Zeolite	1.4	9	150
Carborundum	16.5	53	212

The catalyst employed at the Baltimore plant of U. S. Industrial Chemicals, Inc. was stated to be "silver bonded upon a carrier of aluminum oxide by a fusion process."

A similarly prepared catalyst was subjected to a study of optimum conditions by McBee and associates.[10] Seventy grams corundum (approximately 8-mesh), 21.98 grams silver oxide, and 2.24 grams barium peroxide were mixed in a beaker with 100 ml. distilled water. The slurry was evaporated to dryness while stirred vigorously, and was then dried at 115° C. for ten hours.

At least two catalyst preparations are reported to have been employed commercially by Distillers Company, Ltd., a British Corporation.[11] The older of these is prepared by finely grinding leaf silver and mixing the powder with a paste of gum arabic. The product is thoroughly washed, dried, and screened. It is then briefly heated to 400° C. and is applied to aluminum sticks which serve as carrier.

‡ At elevated temperatures, ethylene oxide can be isomerized to acetaldehyde over a silver catalyst.

The second reported variant of the Distillers Company's catalyst is produced by mixing silver carbonate with corundum and a small amount of gum arabic in a porcelain ball mill. Aluminum rods are immersed into the product which is then dried at 100-150° and finally heated to 400° C. for 30 minutes.

The catalyst developed by I. G. Farbenindustrie[11] is prepared by precipitating silver oxide from a 10 percent silver nitrate solution by means of a 10 percent solution of pure potassium hydroxide (no chloride or sulfide ion!). The product is filtered and thoroughly washed. The wet filter cake is made into a paste and mixed with pumice particles of 6 mm. diameter which have been washed with nitric acid and water. The mass is then gently heated for the removal of water and is reduced by a 5-10 percent hydrogen-in-nitrogen mixture at 150-200° C. The finished catalyst contains about 350 grams of silver per liter.

These catalysts have a life of about one year when operated on gases of satisfactory purity. Reproducibility of results is not very good and the optimum temperature must be determined for each batch. Methods for the regeneration of spent catalysts have not been reported.

McBee and associates[10] noted that the optimum temperature of their silver catalyst increased with its age. Temperature of operation had to be raised by as much as 20° C. to maintain maximum efficiency.

The use of various promoters has been recommended by the patent literature for silver catalysts. There is no indication, however, that the incorporation of a promoter improves the efficiency of ethylene oxide production, or that it has a favorable effect on catalyst life.

The use of "anticatalysts" has been suggested by various patents[12, 13] to suppress the formation of CO_2. Of particular interest is the introduction of small amounts of ethylene dichloride into the feed-gas stream. A process developed by the National Research Council of Canada[14] makes use of this anticatalyst over a modified silver catalyst at rigorously controlled temperatures. While details of this work have not been made available, it is reported that this process can successfully handle refinery absorber residue gases containing as little as 10 percent ethylene by suppressing the oxidation of paraffinic hydrocarbons. McBee[10] has checked the usefulness of ethylene dichloride for this purpose and reports that small amounts of this material have a very favorable effect on the efficiency of the partial oxidation of ethylene. The addition of excessive ethylene dichloride to the gas stream results in poisoning of the catalyst. Catalysts poisoned in this manner can be regenerated by continuing the reaction at a higher temperature in the absence of ethylene dichloride. It is indicated, however, that a catalyst, once poisoned, suffers considerable loss in its life expectancy.

Effect of Process Variables

1) Purity of Raw Materials

The greatest part of the heat of reaction is not due to the production of ethylene oxide but to the formation of by-product carbon dioxide. It is therefore important, from an engineering point of view, to produce as little CO_2 as possible in order not to overtax the heat transfer capacity of the reactor. The presence of non-ethylenic hydrocarbons is undesirable because their combustion will contribute to the heat evolved without doing any useful work. A 97-98 percent ethylene is readily produced and is generally economically feasible. It may sometimes be desirable, however, to employ a lower-grade ethylene. The Societe Francaise de Catalyse Generale states that a feed gas containing 40-50 percent ethylene can be economically utilized for the Lefort process.[9] A feed gas containing 50-60 percent ethylene has been succesfully employed in the United States.[11] The process of the National Research Council of Canada[14] employs a 10 percent ethylene feed but suppresses the oxidation of paraffinic hydrocarbons by the admixture of the "anticatalyst" ethylene dichloride.

The presence of acetylene is exceedingly deleterious to the catalyst and its complete absence must be assured. Special removal of acetylene is essential from ethylene produced from coke-oven gas or by some thermal cracking processes in which acetylene occurs as a by-product. A sizable portion of the I. G. Farben plant at Zweckel was devoted to the hydrogenation of acetylene over a palladium catalyst.

The presence of sulfur compounds in the gas is not permissible.

2) Concentration of Reactants

The ratio of air to ethylene has a very pronounced effect on the conversion. For good yields it is necessary to use a high air : ethylene ratio. The yield rises very rapidly until the ratio of reactants becomes about 7-8. No improvement in yield can be realized by raising the amount of excess air above this value. The permissible ethylene concentration is set by the lower explosive limit which is 3.4 volume percent. The I. G. Farben plant at Zweckel was designed for the addition of ethylene in two stages. In this way, the ethylene concentration in neither stage exceeds 3 percent but the total ethylene volume in a once-through operation corresponds to 5 percent of the recycle-plus-air mixture. The fresh air : ethylene ratio is maintained at 10:1. Further dilution of the gas is brought about by diluting the gas with recycle gas containing a very low percentage of ethylene.

Twigg[15] accounts for the important effect of oxygen concentration by a mechanism involving the adsorption of atomic oxygen on the catalyst surface followed by ethylene oxidation by the adsorbed gas. The adsorption step is rate-controlling for the entire series of reactions and is proportional to the oxygen concentration.

3) Pressure

The stoichiometric equation for the molecular oxidation of ethylene leads to the expectation that pressure has a favorable effect on the production of ethylene oxide.

$$2CH_2=CH_2 + O_2 \rightarrow 2CH_2-CH_2 \quad \text{(decrease in volume)}$$
$$\qquad\qquad\qquad\qquad\qquad\qquad\quad \diagdown\,\diagup \quad O$$

$$CH_2=CH_2 + 3O_2 \rightarrow 2CO_2 + 2H_2O \text{ (no change in volume)}$$

That pressure *does not* have a significant effect on this process has been stated by Curme[9] and is further evidence in support of the mechanism proposed by Twigg (see above).

4) Temperature

The optimum temperature of operation may be between 150 and 400° C., depending on the activity of the catalyst, the ethylene and oxygen concentration, and the gas velocity. McBee[10] has made an accurate study of the yields at various temperatures over one particular silver catalyst and finds that a very definite optimum temperature exists for any flow rate and gas composition. Above this temperature, the formation of CO_2 becomes excessive. At lower temperatures, the conversion per pass is unsatisfactory. The conversion is, of course, somewhat smaller than the yield if part of the effluent ethylene is recycled. Since a sizable portion of the unconverted ethylene must be wasted, however, it is not possible to realize the full efficiency of the catalyst. A slight improvement in yield can be obtained at any one temperature by increasing the contact time above the customary 1½-4

seconds. The required increase in equipment size limits this possibility.

As the catalyst ages, the operating temperature must be gradually raised. Eventually a point is reached where the formation of carbon dioxide becomes economically unbearable and the catalyst must be changed. The life of a good catalyst is in excess of one year.

5) *Gas Velocity*

The proper gas velocity is a function of the activity of the catalyst and the temperature of operation. The conversion per pass increases as a direct function of contact time; the over-all yield is not affected. The permissible contact time is limited by economic considerations.

6) *Moisture Content*

Contrary to the statements in Lefort's original patents, the presence of water in the feed gas is without significant effect on the conversion. The presence of 1-2 percent moisture tends to stabilize the reaction, minimizing the danger of runaway temperatures. Very high steam concentrations result in partial hydrolysis of ethylene oxide in the gas phase. In industrial practice, the gases are generally saturated with water vapor at the temperature of the surroundings.

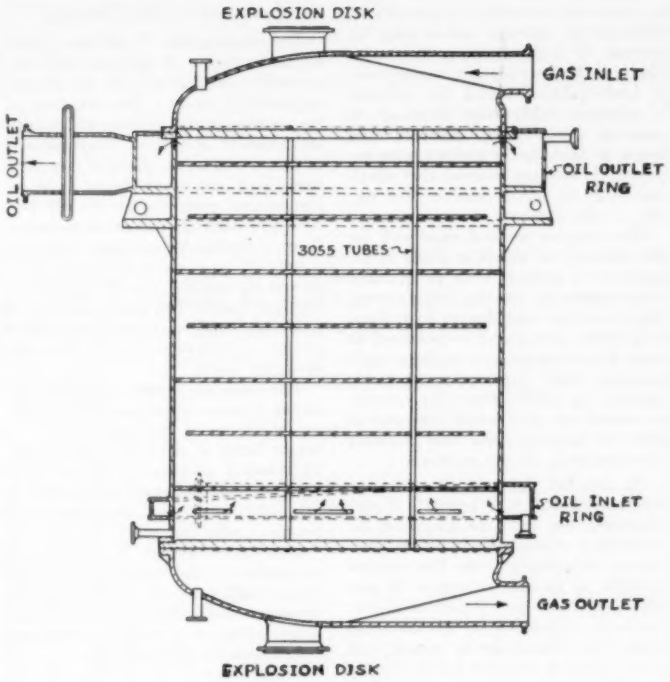


FIGURE 3
Oil Cooled Reactor for the Oxidation of Ethylene to Ethylene Oxide.

Heat of Reaction and Reactor Design

Considerable heat is evolved during the partial oxidation of ethylene. Since it is generally desired to operate within comparatively narrow temperature limits, means must be provided for removing large quantities of heat from the reaction zone.

The heat due to the useful formation of ethylene oxide is only a small fraction of the total; most of the heat of reaction stems from the complete combustion of ethylene to carbon dioxide and water.

At 291° C:

$2C_2H_4 + O_2 = 2C_2H_4O + 56$ kcal.

$2C_2H_4 + 6O_2 = 4CO_2 + 4H_2O + 631$ kcal.

If the reaction is operated with 50 percent efficiency, only 8.1 percent of the total heat is due to the formation of ethylene oxide. The very high cost of the reaction equipment is therefore entirely due to the formation of undesired CO_2. Improvement of the reaction efficiency will have the dual advantage of ethylene saving and a very appreciable reduction in initial plant cost. Figure 2 shows the effect of reaction efficiency on the heat evolved per pound of ethylene oxide formed. While the process is generally operated with a yield, based on ethylene, of only about 50 percent, a much higher efficiency is essential in order to keep the problem of heat removal within tolerable limits.

The reaction equipment must be designed for excellent heat removal and proper temperature control. Reactors of the type generally employed for the oxidation of naphthalene to phthalic anhydride fulfill the requirements of ethylene oxidation; the problem of heat removal is of the same order of magnitude in both cases.

Figure 3 shows a typical reactor employed for the ethylene oxidation reaction. This particular design is that of I. G. Farbenindustrie. The catalyst is arranged inside 3055 internally galvanized (or preferably stainless steel) tubes which are tapered in order to maintain approximately the same gas velocity at all points. The cooling medium (oil or water) enters at the bottom of the reactor through side openings in the jacket which are carefully arranged to maintain uniformity of oil flow at all points. After traversing the reactor countercurrently to the gas stream, the cooling medium leaves the top of the jacket through outlet openings spaced uniformly along the periphery.

The choice of corrosion-resistant materials is essential. The presence of rust inside the reactor tubes would catalyze the formation of formaldehyde and formic acid and the complete combustion of ethylene.

For the purpose of obtaining better heat exchange in the reactor, operation at elevated pressures has been suggested and is believed to be practiced by at least one firm.

The application of fluidized-catalyst technique to ethylene oxidation has been patented[10] but does not seem to have been adopted on a commercial scale.

Purification of the Product

The product of the reaction contains essentially only dilute ethylene oxide together with unreacted ethylene, nitrogen, oxygen, carbon dioxide, and water. The separation and purification of the product can be effected without great difficulties. Distillers Co., Ltd.[11] adsorbed ethylene oxide on activated charcoal which was periodically regenerated. In order to avoid the formation of glycol, which is removed only with difficulty from the carbon,

it is necessary to avoid the presence of alkali in the charcoal and to keep the amount of moisture at a minimum. The I. G. Farbenindustrie laboratories at Ludwigshafen found the removal of ethylene oxide from charcoal by steaming to be very difficult, and losses as high as 50 percent were reported. It was conjectured that ethylene oxide is polymerized on the surface of the charcoal.

The common method employed for the recovery of ethylene oxide is absorption in sulfuric acid, or in water under pressure. In the former case, the product is immediately hydrolized to ethylene glycol and is recovered as such. The absorption of ethylene oxide in water under pressure is especially suitable for plants where the reaction is carried out at elevated pressures in order to improve the heat-transfer characteristics of the reactor.

At Zweckel the acid concentration was maintained at 1 percent. Higher concentrations must be avoided because they promote unduly large formation of higher glycols. The solution is built up to approximately 20 percent glycol content. A portion is continuously withdrawn for further treatment. The remainder is mixed with make-up water and acid and is recycled through the absorption system. Two rubber-lined, Raschig ring-packed absorption towers are used in series. Each is 35 feet high. The absorption takes place at 45 psi.

After withdrawal from the absorption system, the glycol solution is neutralized with caustic soda. It is then concentrated to 90 percent glycol content in a vacuum evaporator and is desalted.

Final treatment is the removal of water in continuous vacuum stills. The bottoms are separated into ethylene glycol, di-glycol, and tri-glycol by fractionation at 60-70 mm. Hg. Ethylene glycol makes up 80-85 percent of the total glycols produced.

Economics of the Process

The manufacture of ethylene glycol by air oxidation of ethylene is fundamentally competitive with the chlorohydrination process. The selection of the more economic process will depend on a variety of factors. The first cost of an air oxidation plant is comparatively high, exceeding that of a chlorohydrination plant by 50 to 100 percent. The catalytic process is moreover more wasteful of ethylene. Approximately 117 pounds of ethylene are required to manufacture 100 pounds of ethylene oxide. The same quantity of oxide can be manufactured from 80-90 pounds of ethylene via the chlorohydrination route.

The main advantage of the air oxidation process is the use of an oxidizing medium at negligible cost. A major factor in the cost of the chlorohydrination process is the price of chlorine which is consumed at the rate of slightly more than two pounds per pound of ethylene oxide.

Ethylene dichloride is formed as a by-product in the manufacture of ethylene oxide or glycol by the chlorohydrination route. Depending on the economic situation, a suitable credit may be allowed for this material.

It is difficult to see how the air oxidation process, in its present form, could be employed economically in European countries where ethylene must be produced from coke-oven gas, acetylene, or ethanol, and its price is correspondingly high. In the United States, cheap ethylene makes the process much more attractive.

At present, high construction costs make the air oxidation process in new plants almost prohibitive. Depreciation of a plant built in 1943, its maintenance, etc., would account for nearly 9-10 cents per pound of glycol which is today quoted at a market price of 12 cents. This is one of the principal reasons why Jefferson Chemical Corporation and Wyandotte prefer to use the classical chlorohydrination process in their new plants in spite of the short supply of chlorine.

The picture looks quite different for plants which are built during times of more reasonable construction costs. Plant costs at 1938 standards would make the production of ethylene glycol at ten cents per pound quite possible.

An appreciable increase in chlorine prices would force a boost in the market price of ethylene glycol. The picture would then, once more, change in favor of the air oxidation process and the construction of a new catalytic plant employing this procedure might once again be justified.

The future of the direct oxidation process lies in the improvement of its efficiency which will reduce the first investment costs very appreciably and will lower the raw materials consumption.

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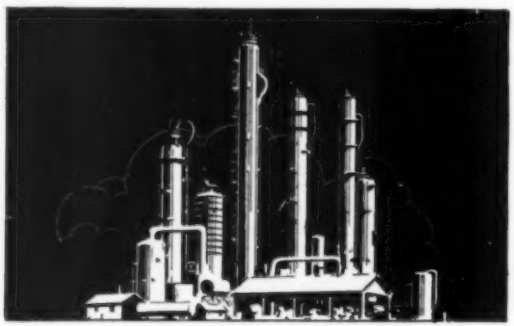


Cycle Washing Of Percolation Filters

E. J. REEVES
and R. E. TURKLESON

Technical Department, Refining Division, Magnolia Petroleum Company, Beaumont, Texas

***THE OPERATING** costs of processes employing solvents for filter washing are to a large degree dependent upon the cost of solvent redistillation. This cost in turn is directly proportional to the amount of solvent circulated through the filtration apparatus. The authors of this article report experimental results indicating that cycle washing of filters can be accomplished with some 25 percent of the fresh solvent flow volume required by the more usual procedure employing fresh naphtha for each washing contact.*

PERCOLATION of lubricating oils for color improvement is employed extensively in petroleum refining operations. The spent adsorbent in the filters must be washed with a solvent to recover the entrapped oil and to permit satisfactory regeneration of the clay. Because of its low cost and availability to the refiner the solvent most frequently used is a narrow boiling, highly paraffinic naphtha fraction.

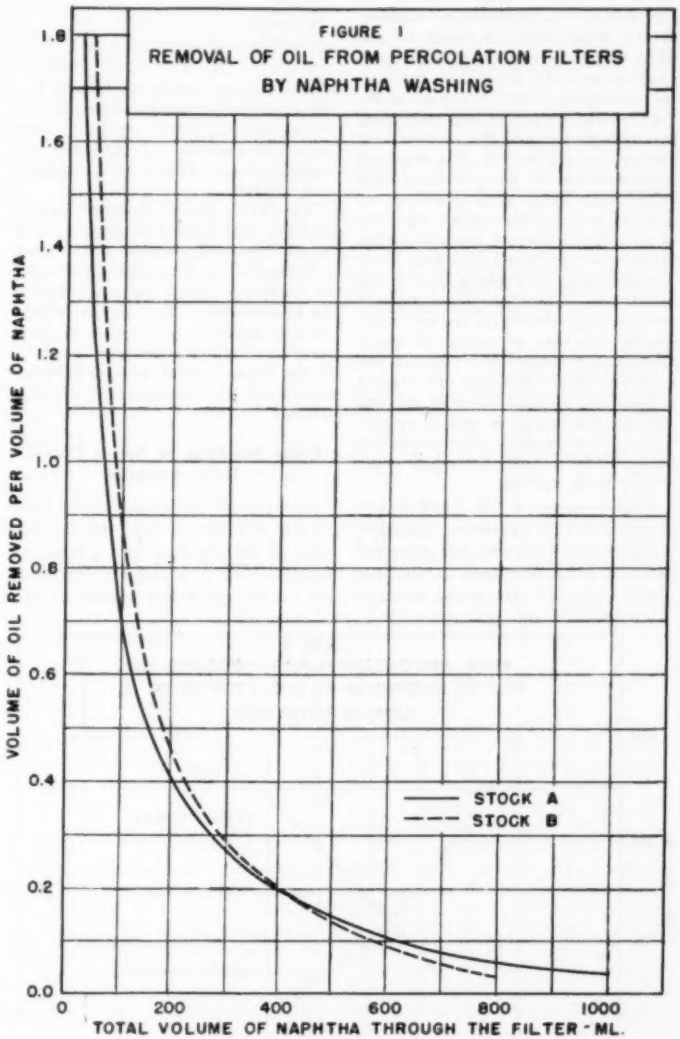
The clay wash solution is distilled to recover the naphtha and oil, the naphtha for reuse on subsequent filters and the oil for refiltering. To reduce these distillation costs and prevent excessive utilization of valuable redistillation capacity which may be used for other services, it is desirable that a minimum amount of naphtha be employed. The volume of naphtha required for washing filters to a predetermined oil content of the rejected clay depends on a number of variables such as:

1) Solvent characteristics of the naphtha.
2) Properties of the adsorbent.
3) Temperature of the clay bed.
4) Temperature of wash naphtha.
5) Properties of oil adsorbed by the clay.
6) Method of applying naphtha to the adsorbent.

The last variable offers the greatest promise in effecting refinery savings, and was therefore chosen for the present studies. In the usual refinery procedure, fresh naphtha is employed throughout the washing cycle until the oil content of the clay reaches the desired minimum. This paper presents the results of laboratory work demonstrating that a considerable reduction in fresh naphtha may be effected by introducing cycle washing, i.e., washing with a portion of the oil-naphtha mixture from a previous filter.

Cycle wash was applied in the following manner: Naphtha from the fil-

FIGURE 1
REMOVAL OF OIL FROM PERCOLATION FILTERS BY NAPHTHA WASHING



ters was divided into two portions. The first portion, rich in oil, was sent to the naphtha recovery system, while the second portion, containing relatively small quantities of oil, was used for preliminary washing of the next filter. Washing of this second filter was completed with fresh naphtha. The first portion of the filtrate from the second filter was sent to the naphtha recovery system while the second portion containing relatively small quantities of oil was used for preliminary washing of the third filter. Washing of the third filter was completed with fresh naphtha and the procedure repeated for succeeding filters. The wash naphtha could be separated into more than the two portions, thus effecting greater economies, but this was not done because of complications that would arise from large scale operations in keeping the washes separate. In all the experiments, washing of the filters was considered complete when the oil content of naphtha leaving the filters was reduced to 3-3.5 percent volume. This effluent oil content corresponds to a clay oil content of about 2.5 percent weight. The naphtha required to attain this clay oil content (2.5 percent weight) was 1000 ml. and 800 ml. for Stocks A and B, respectively, when washing the laboratory filters by the normal procedure using wholly fresh naphtha.

In the course of this work it was observed that the procedure, described above, could be considerably shortened by employing unfiltered oil-naphtha blends instead of oil-naphtha mixtures obtained from recycle operations. For the experiments, presented herein, the spent filters were washed with measured quantities of unfiltered oil-naphtha blends before fresh naphtha was applied.

Table 1

Calculation of fresh and discard naphtha volumes for a recycle naphtha of 20 percent volume oil content.

Naphtha Effluent ml.	Removed Oil ml.	Recycle Oil ml.	Effluent Oil ml.	Cumulative Oil Effluent ml.	Oil Content of Stream Effluent Percent Volume
0— 100	150.0	25.0	175.0	175.0	64.0
100— 200	53.2	25.0	78.2	253.2	44.0
200— 300	32.8	25.0	57.8	311.0	37.0
300— 400	24.0	25.0	49.0	360.0	33.0
400— 500	18.0	25.0	43.0	403.0	30.0
500— 600	13.5	25.0	38.5	441.5	28.0
600— 700	9.5	25.0	34.5	476.0	26.0
700— 800	7.0	25.0	32.0	508.0	24.0
800— 900	5.0	...	5.0	513.0	4.8
900—1000	3.5	...	3.5	516.5	3.4

The terms fresh naphtha, recycle naphtha, and discard naphtha as used in all further discussions are defined as follows: "Fresh" naphtha is the zero oil content naphtha used to complete the filter washing. "Recycle" naphtha is the oily naphtha employed as the first wash on the filters. "Discard" naphtha is the naphtha sent to redistillation equipment for recovery of naphtha and oil.

Cycle Washing of Spent Filters With Naphtha

Analysis of the experimental data plotted in Figure 1 shows that the volume of oil removed per volume of naphtha used in washing is independent of the initial oil content of the wash naphtha within the range studied, 0 to 40 percent volume oil. The washing curves obtained with Stocks A and B were very similar, suggesting that they may coincide if the viscosities of the two stocks were equal. Viscosity of Stock A at the washing temperature of 180° F. was 21.9 cp., or 150 Saybolt seconds universal, and that of Stock B at the washing temperature of 130° F. was 17.1 cp., or 100 SSU.

Data showing the amounts of fresh naphtha required to obtain the aforementioned low oil content of the effluent naphtha and the amounts of discard naphtha for various recycle oil contents are presented in Figures 2 and 3. In these experiments 1000 ml. of recycle naphtha of various oil contents were used for preliminary washing of the filters from Stock A and 750 ml. for the filters from Stock B. This was followed by quantities of fresh naphtha sufficient to reduce the oil content of naphtha leaving the filters to 3.5 percent volume. The discarded naphtha in these experiments corresponded to that portion of recycle naphtha which carried with it the total amount of oil which must be eventually removed from the filters.

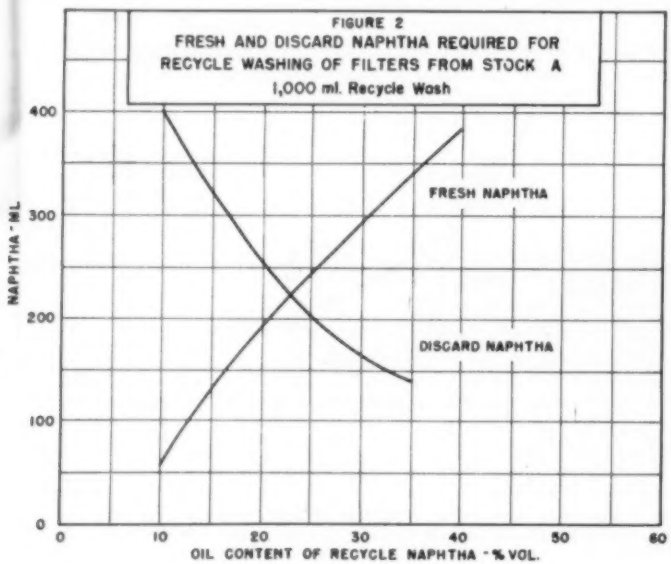
In plant application of cycle washing, it is imperative that the volume of discard naphtha be equal to the volume of fresh naphtha. If these quantities are not equal, composition of the recycle wash will vary and the maximum decrease in volume of clay wash solution will not be achieved. This point of balanced operation corresponds to the intersection of the two curves prepared for each of the two stocks investigated and demands that the oil content of recycle naphtha be 23 percent volume. These data show that fresh naphtha requirements when using recycle washing are 250 ml. for Stock A and 200 ml. for Stock B. A 75 percent reduction in fresh naphtha may thus be secured by applying recycle washing.

The fresh and discard naphtha quantities at various oil contents of recycle naphtha can be easily calculated from

FIGURE 2

FRESH AND DISCARD NAPHTHA REQUIRED FOR RECYCLE WASHING OF FILTERS FROM STOCK A

1,000 ml. Recycle Wash



data presented in Figure 1. An example of the calculations for Stock A is shown in Table 1.

The oil removed, Column 2, is obtained by integration of the relation presented in Figure 1 between the naphtha effluent limits shown in the first column. Thus, the total oil removed from the clay (316.5 ml.) is the summation of these incremental integrals, 150.0, 53.2, 32.8, etc., or the total area under the curve. Assuming no adsorption of oil from the recycle wash, the effluent must contain the oil originally present in the recycle naphtha plus the oil removed. The volume of recycle oil present in the naphtha effluent is shown in Column 3. Effluent oil, Column 4, is obtained by addition of values in Columns 2 and 3. The cumulative effluent oil, shown in Column 5, is a running total of the data in Column 4. The effluent is discarded or, in practice, pumped to redistillation equipment when the cumulative effluent oil is equal to the total oil (316.5 ml.) which must be removed from the clay. The discard naphtha is the quantity of naphtha in which the removed oil is dissolved and is approximately 310 ml.

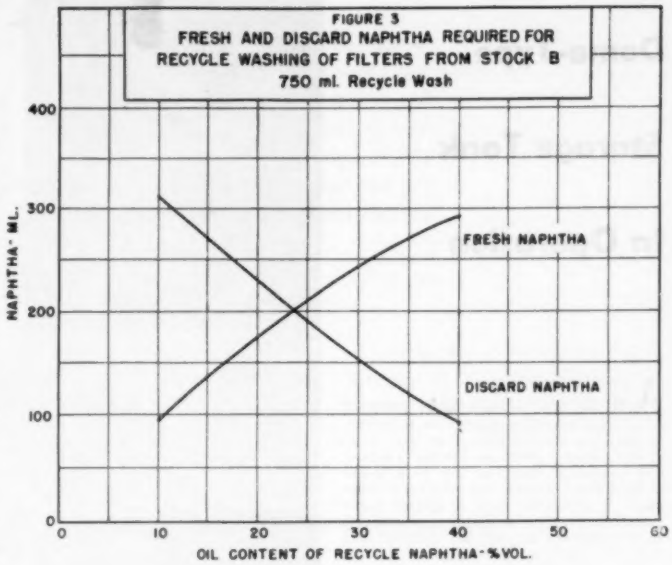
Utilization of Recycle Wash

For practical purposes, the recycle wash is considered to be utilized to its maximum efficiency when the oil content of the effluent stream approaches to within 3.5 percent of the unfiltered oil-naphtha blend. This means that when the calculated effluent stream oil content is 23.5 percent volume, Column 6, application of recycle wash should be discontinued and fresh naphtha applied. At this point, the total naphtha effluent as indicated in Column 1 would be about 850 ml., all of which would be obtained from a 20 percent volume oil content recycle naphtha.

Fresh naphtha would then be applied and the washing continued until the clay oil content reaches the desired level. Oil removal is considered complete when the naphtha effluent has an oil content of 3-3.5 percent volume oil. As shown by the data in Columns 1 and 6, the fresh naphtha necessary to obtain a 3.4 percent volume oil content is about 150 ml., or the difference between the 1000 ml. total naphtha required and the 850 ml. of recycle naphtha.

Table 2
Comparison of calculated and experimental cycle washing data.

	Calculated	Experimental
Recycle naphtha, ml.	1050	1000
Total oil removed, ml.	316	310
Naphtha discard, ml.	310	250
Fresh naphtha, ml.	150	190



Experimental discard and fresh naphtha quantities for a 20 percent volume oil content recycle naphtha are in agreement, as shown in Table 2, with the calculated data.

Several calculations at recycle oil contents varying between 0-40 percent oil must be made. The balanced operating point where the fresh and discard naphtha are equal can then be determined by interpolation.

The laboratory filters used in this work were 1⅞ inches in diameter and 30 inches high and were immersed in an oil bath in order to insure a uniform temperature during the washing experiments. The bath temperature was maintained at 180° F. for residual oils and at 130° F. for distillate stocks. Each filter contained 900 ml. of clay, regenerated on the plant Thermofor kiln.

Residual Stock A was percolated to a composite 8 ASTM color and distillate Stock B to a composite 4 ASTM color before the entrapped oil was washed from the clay with naphtha. Properties of these stocks are shown in Table 3.

Table 3
Properties of lubricating oil Stocks A and B.

Properties	Stock A	Stock B
Gravity, °API	26.8	29.2
Flash, °F.	520	430
Color, ASTM	D. Green	D 4½
Pour, °F.	20	20
SU at 100° F.	1113	192.1
SU at 210° F.	100.7	46.0
Viscosity Index	103	99.2

Table 4
Properties of wash naphtha.

Properties	Naphtha
Gravity, °API	48.4
Flash, °F.	110
Color, Saybolt	25
Aniline No., °F.	134
Distillation, °F.:	
IBP	315
10 percent	327
50 percent	344
90 percent	367
EP	434
Recovery percent	98

Properties of the naphtha employed are shown in Table 4.

Conclusions

Specific conclusions developed from the data are summarized as follows:

1) The volume of oil removed per volume of wash naphtha is independent of the initial oil content of the recycle naphtha within the range of 0 to 40 percent oil.

2) The composition of the recycle naphtha under equilibrium condition, where fresh and discard naphtha quantities are equal, is about 23 percent volume oil and 77 percent volume naphtha for the stocks investigated.

3) The volume of fresh naphtha required to wash the filters on application of cycle washing is 75 percent below that required when using the normal procedure.

ACKNOWLEDGMENT

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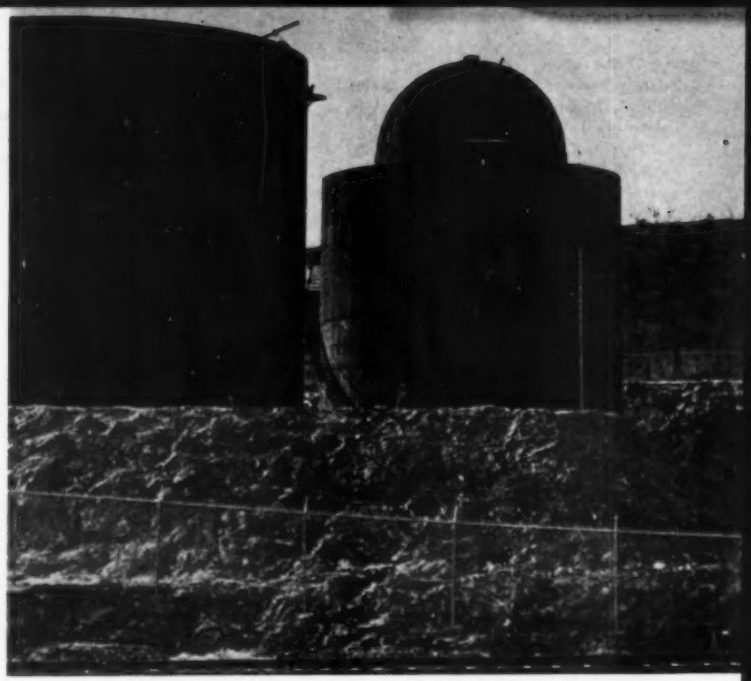
Dome-Type Storage Tank In Operation



New Dome-Type Storage Tank Designed to Reduce Standing Storage Evaporation Losses Put Into Operation by Socony-Vacuum Oil Company, Inc., at its Worcester, Mass., Plant.

A NEW type storage tank, designed to prevent loss of gasoline due to evaporation, has been installed at the Worcester, Mass., plant of Socony-Vacuum Oil Company, Inc. The new tank essentially a flat-bottom, cone-roof oil storage tank, is equipped with a special dome containing a flexible diaphragm made of nylon coated with perbunan rubber. The tank is called a "Vapordome."

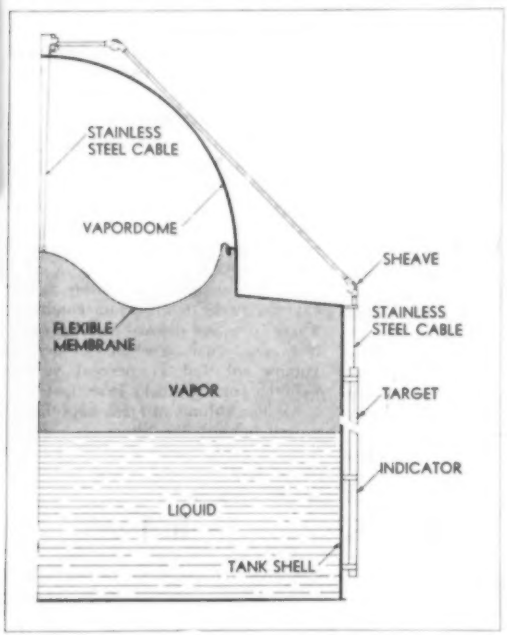
This special roof provides a variable-volume space so that when vapors expand in the tank, which occurs to a greater extent in warm weather, the diaphragm expands inside the steel dome. The vapors are held within the tank, instead of being vented to the atmosphere. Thus standing storage evaporation losses are reduced. When the temperature decreases, the diaphragm contracts; however, air is not drawn into the tank to mix with the vapors. Instead, the air is drawn into the space between the diaphragm and the steel dome.

Construction of a vapordome tank is the same as for a flat-bottom tank having a cone roof, with the exception that the vapordome is a hemisphere of lap-welded 3/16-inch steel plates in the center of the roof and supported on three equally spaced columns. The cone roof has a pitch of 1½ to 12. The flexible hemispherical membrane of the same diameter as the dome, is made of nylon fabric coated on both sides with petroleum-resistant synthetic rubber. It is attached by its outer edge to the equator of the dome and is free to hang downward in the form of a hemisphere. The available expansion volume is equal to the volume of a sphere of the same diameter.

According to Chicago Bridge & Iron Company, builder of the vapordome roof, the tank may be used as a single unit, or it may be connected by vapor lines to the vapor spaces of other tanks having fixed roofs. Interconnecting the tanks permits vapors to flow from one tank to another, when various tanks in the system are being filled and emptied simultaneously, to provide a balancing action and prevent vapor losses. The reserve capacity of the dome, not required for breathing, can be used for these vapors.

The tank is equipped with an indicator to show the approximate position of the flexible membrane. A conventional indicator board and target is fastened to the outside of the tank shell. The target is actuated through connection to the membrane by a light stainless steel cable. To protect the vapordome roof against excessive pressure or vacuum, a conservation vent is mounted on the cone-roof of the tank.

The oddly-shaped tank is the first of its kind to be placed in operation by Socony-Vacuum and is the first built in this country. All the moving parts of the tank are protected from the wind and weather. Vents, gauges and other tank fittings have been simplified for use on the vapordome.



Cross-Sectional View Showing Some of Construction and Operation Details.

A RAPID method of constructing approximate Mollier diagrams for pure hydrocarbons is outlined and illustrated in this installment. This procedure makes full use of all generalized correlations and shortcuts, employing the minimum data on the properties of the hydrocarbon. A comparison is made between the approximate and rigorous methods of constructing Mollier diagrams.

Applications of Thermodynamics To Hydrocarbon Processing

WAYNE C. EDMISTER
Professor of Chemical Engineering,
Carnegie Institute of Technology,
Pittsburgh

PART XVII—Enthalpy-Entropy Plots for Pure Hydrocarbons

THE preparation of precise and extensive charts and tables of thermodynamic properties, such as those existing for some fluids (steam, ammonia, methane, ethylene, ethane, etc.), involves a great deal of very careful calculations and graphical work, based on very accurate data. Compilations of this kind are full-grown projects and not just auxiliaries to a plant process design project. It is frequently necessary to prepare a portion (or all) of a Mollier diagram rapidly from very few data. Both types of thermodynamic compilation have places as useful design tools for process engineers.

These two procedures will be referred to as: the *rigorous method* and the *approximate method*, which terms refer to the development procedures rather than the resulting charts or tables. With inaccurate data, the rigorous method will not yield precise results. The rigorous method should not be applied to questionable data. In some cases it is better to use generalizations and be approximately correct than to use poor data and run the risk of being badly in error.

During the past 20 years many thermodynamic compilations have been developed for the hydrocarbons. Some of these have been rather widely used. Most of the earlier compilations should be discarded in favor of more recent and accurate charts and tables. An objective of this installment is to call the readers attention to one set of erroneous charts. The primary objective is to present the procedures for developing thermodynamic compilations.

The calculations for and the construction of a Mollier diagram for a perfect gas were included in Part IV (REFINER, October, 1947). Real fluids differ in two important respects, namely: the enthalpy is a function of both temperature and pressure for an actual gas and an actual gas will have a vapor-liquid region.

Types of H-S Compilation

In addition to tabulations of properties, there are five different plots that may be prepared to present the data. These plots employ the variables, P, T, V, H and S in the following manner:

TYPE	Abscissa	Ordinate	Parameters
1	T	H	P
2	T	S	P, V and H
3	S	H	P, T and V
4	H	P	T, S and V
5	V	H	P, T and S

Types 1 and 2 are the most obvious way of plotting entropies and enthalpies and are usually the preliminaries of Types 3 and 4. Type 3 is the type of diagram first called "Mollier," after the man who first constructed it. Type 3 is commonly used in making steam power calculations. Type 4, which is usually ploted on semi-log paper with pressure on the log-scale, is used in making refrigeration calculations. Type 5 is known as the "Ellenwood" diagram. It is useful in steam design calculations where changes in both volume and enthalpy are required.

The Mollier diagram for steam has long been a very useful tool of the engineer. From it changes in enthalpy and volume may be found for isothermal, isobaric or isentropic paths. Also changes in entropy, pressure and temperature may be readily found. Among the many uses of the steam Mollier diagram are 1) the calculation of the flow velocity from a nozzle, jet or orifice; 2) the calculation of work done by the steam on a turbine wheel; and 3) the calculation of losses by throttling or wire-drawing.

Mollier diagrams and tables of thermodynamic properties have been prepared for other fluids, particularly those fluids used as refrigerants; such as NH_3, SO_2, CO_2, the Freons and some of the hydrocarbons. Most of the Mollier diagrams have been of Type 4.

A comprehensive and consistent set of Mollier diagrams for hydrocarbons would be most valuable to process engineers engaged in design work. Such a set of charts and tables should have consistent datum points for the entropy and enthalpy. They should also be prepared in consistent units. Neither of these uniformities exist in the previous and present work on this subject.

This need for consistency in units and datum is clearly obvious in calculations dealing with hydrocarbons mixtures. For mixtures, it is also

necessary to have methods of estimating phase equilibria conditions and of combining pure component properties to obtain those for the mixture. Both of these should take into account deviations from ideal mixtures and solutions.

Engineering units have been used in most compilations made in this country. An exception being the use of atmospheres instead of psia. for pressure by York and co-workers.[18, 25] Since psia. is used in the compilations for steam and other non-hydrocarbon fluids, it would seem that this pressure unit should also be used for hydrocarbon compilations as well. Values of V, H and S have been based on one pound of the fluid. A pound mol basis would be more convenient for calculations dealing with reactions, as will be pointed out below in connection with the datum.

Datum

There is considerable divergence among different authors on the datum point used. The following have been used for some of the non-hydrocarbon fluids:

Steam	Sat. Liq. at 32° F.
Ammonia	Sat. Liq. at — 40° F.
Methyl Chloride	Sat. Liq. at —100° F.
Freons	Sat. Liq. at — 40° F.

These temperatures correspond to different saturation pressures, even where the temperatures are the same. For refrigeration calculations, where a single pure substance is used in a compression cycle, the datum may be any convenient point. Most Mollier charts and tabulations are based on a sufficiently low datum point to give all positive and no negative values of entropy and enthalpy. This would not be necessary, however, as the important things are to find differences in enthalpies and to follow a line of constant entropy in the compression calculations.

In developing a set of charts for hydrocarbons that can be used for any of the various types of calculations, the selection of the datum is more important. Since steam is used in practically all hydrocarbon processes it would appear that the datum used for steam should be used for hydrocarbons as well. This is complicated by the fact that the lower boiling hydrocarbons will not be liquid at 32° F., no matter how high the pressure. One set of enthalpy-temperature charts, known to the writer but never published, used saturated liquid at —200° F. as the H = 0 point. Other datum points employed in the development of hydrocarbon Mollier diagrams are:

Methane	Sat. Liq. at —258° F.
Ethylene	Sat. Liq. at one atmosphere
N-Butane	Sat. Liq. at one atmosphere
Ethane	Solid at 0° R.
Benzene	Solid at 0° R.

These are certainly not consistent reference states.

Saturated liquid at the atmospheric boiling point is not a logical datum because each hydrocarbon has a different boiling point temperature. Saturated liquid at any given temperature (below the critical of the lightest component) is not a logical datum because each hydrocarbon will have a different saturation pressure at this temperature.

The ideal gas state at any temperature would make a good datum. If ideal gas at 25° C. were used as the reference state, the resulting thermodynamic properties would tie-in well with the tabulated data on heats of formations, free energies, etc., used in making reaction calculations. An objection to this datum is the fact that it would give negative values of enthalpy in some ranges, such as saturated liquid. From a practical standpoint, this would be inconvenient.

Ideal gas at absolute zero (—459.7° F.) would be another logical datum. Referring entropies and enthalpies to this reference point would involve extrapolating the ideal gas state heat capacity equation to these low temperatures in performing the integration. At absolute zero temperature the heat capacity of an ideal gas is zero. An advantage of this datum is that Rossini et al.[21] have computed and tabulated the entropy and enthalpy values for hydrocarbons above this reference point. In other words, S = 0 and H = 0 at —459.7° F. This Bureau of Standards compilation takes care of the effect of temperature on the entropy and enthalpy of pure hydrocarbons.

For hydrocarbon reaction calculations it would be convenient to have the heat of formation included in the enthalpy values so that heat balances could be readily made for reactions. This could be done with any consistent datum such as ideal gas at 25° C. or —459.7° F. Rossini et al.[21] also tabulate values of the heat of formation for the hydrocarbons, the values being given at several temperatures from 0° K. upwards, which values represent the increments for the reaction of forming the hydrocarbon from carbon (crystalline graphite) and hydrogen (gaseous), with all the reactants and products at their standard reference state (i.e. ideal gas state).

It would be a simple matter to combine the values of the ideal gas state enthalpy above —459.7° F. with the heats of formation, both from the Bureau of Standards Circular C-461, to obtain hydrocarbon enthalpies above the elements. Such values should be on a pound mole basis in order to be of most value for reaction calculations.

For reactions involving steam, the enthalpy values of steam should also be referred to the same datum, i. e. gaseous hydrogen and oxygen at —459.7° F. This may be accomplished by converting the enthalpies given in the steam tables by adding the appropriate values and multiplying by the molecular weight of steam. Similar compilation would be required for hydrogen, oxygen, carbon, etc. Fortunately, Rossini et al.[21] have computed and tabulated these values as well.

The entropy values included in the proposed set of thermodynamic properties could likewise be referred to the elements but there is not as much advantage in having absolute entropies because of the fact that reaction equilibrium calculations are made with equilibrium constants for the ideal gas state and then corrected for pressure by means of fugacities. Where the change in free energy is required for any reaction, it would be convenient to have absolute entropies, as well as enthalpies, as a function of temperature and pressure, however.

The base pressure used in evaluating the R ln P term in the calculation of entropy should be standardized. Three pressures have been used by different investigators: 1 psia., 10 psia., and 1 atmosphere. Barkelew et al.[2] used 1 psia., while York et al.[18, 25] used 1 atmosphere. This difference in pressure makes an appreciable difference in the numerical values of the entropy. Where only one hydrocarbon is involved in calculations, it doesn't matter what base pressure is used. For a series or set of charts on hydrocarbons, it would be best to use the same pressure, however.

It is not within the scope of this installment to develop compilations of thermodynamic properties of hydrocarbons. The objective is to outline and illustrate the procedures that may be followed. The use of Bureau of Standards Circular C-461 is recommended as the basis for any compilations of hydrocarbons thermodynamic properties.

Development Procedure

Two procedures will be described for developing tables and charts of thermodynamic properties of hydrocarbons, i. e. the *rigorous* and the *approximate* methods. Either is appli-

cable in the preparation of compilations for any purpose, such as refrigeration cycles, reactions, etc.

In either method, *rigorous* or *approximate*, the general procedure is the same: a) select datum (include heat of formation where desired), b) compute the effects of temperature on the properties at some one pressure, c) compute the effect of pressure on the properties at various temperatures, d) establish the vapor pressure-temperature relationship, e) compute the change in properties during vaporization, f) combine these results to obtain the properties of saturated liquid, saturated vapor and superheated vapor above the datum, and g) prepare tabulations and charts.

The calculations involved in these steps may be graphical, analytical, or a combination, depending upon the particular circumstances. For the effect of temperature and the heats of formation, the Bureau of Standards [21] compilation is recommended for those substances covered. For other substances heat capacities must be obtained or estimated.

Rigorous Method

For the *rigorous* method the following data are required: a) vapor pressures, including atmospheric boiling point and the critical conditions, b) P-V-T data for the superheated vapor, c) densities of the saturated liquid and vapor, d) ideal gas state heat capacities, and e) one value of the heat of formation. When there are several sources of data available, the selection of the best data to use in the calculations is an important step. This involves a careful examination of all the data and the methods used in obtaining them. Fortunately, Rossini et al.[21] have done this work for some of the properties. They include the latent heat of vaporization at 25° C., which gives a one point check of computed values. Spencer [23] presents empirical heat capacity equations for many substances, including the hydrocarbons covered by Rossini et al.[21] The values selected by Rossini et al.[21] for hydrocarbons were used by Spencer.

With these data, the procedure used in developing tables and charts of thermodynamic properties is as follows:

Step 1—Correlate and smooth the vapor pressure data by an equation or large scale graph and tabulate values of temperature for even values of pressure and vice versa.

Step 2—Correlate and smooth the saturated liquid and vapor densities by a large scale graph and tabulate density values for the temperature values from the previous step.

Step 3—From the vapor pressure correlation derived in Step 1 and the densities for saturated liquids and vapors obtained in Step 2, compute the latent heat of vaporization by means of equation 51a (Part XIV, Refiner, December, 1948).

Fourth Step

Step 4—Correlate and smooth the P-V-T data by means of an equation of state or by large scale graphs or by both, using graphs to correlate the residual, i. e. the difference between the equation of state and the actual values. For best results, a precise equation of state, such as the Beattie-Bridgeman or the Benedict et al. equations, should be used.

Step 5—From the available data, experimental or spectroscopic, derive an equation for the ideal gas state heat capacity.

Step 6—Integrate the ideal gas state heat capacity equation and compute the effect of temperature on entropy and enthalpy, above the selected reference temperature. Alternately, use the values of H and S given in Bureau of Standards Circular C-461.[21]

Step 7—From the P-V-T correlation, compute the isothermal effects of pressure, above the ideal gas state on the entropy and enthalpy of the superheated vapor. This may be done directly if the P-V-T correlation is explicit in volume or it may be done via the internal energy plus the PV term if an equation of state explicit in pressure is used.

Step 8—From the P-V-T correlation compute values of V for different even values of pressures and temperatures. Also compute values of P for lines of constant volume at different temperatures. These results are for the tables and the Mollier diagram, respectively.

Step 9—Combine all the results from the previous steps into comprehensive tables and charts. In doing this it is desirable to prepare large scale plots in order to check the results for continuity and smoothness. Additional auxiliary plots, such as T-S and H-T diagrams are useful in this graphical construction. In this step the two phase (vapor-liquid) border curve is located at the appropriate place by means of the P-T relationship and the enthalpy values.

In combining these results, it is best to use the ideal gas state (zero pressure) line as the base line for construction, locating all other parameters, including the saturated vapor and liquid curves, relative to this ideal gas state line.

Step 10—If the Mollier diagram and the table of thermodynamic properties are to include the heat of formation, this may be done by using the value of ΔH_f in calculating the effect of temperature or it may be done at the end by adding the proper value.

The above operations need not be carried out in the exact order listed. Some of the operations may be carried out simultaneously.

It is worthwhile to have experimental values of Joule-Thomson coefficient, higher pressure heat capacities, etc. for checking the results of calculations from P-V-T. However, if the P-V-T are precise, the calculated results should be the most accurate.

Approximate Method

For the *approximate* method of developing tables of thermodynamic properties and a Mollier diagram, the minimum data required are the atmospheric boiling point and critical constants. With these data it is possible to estimate volumes, entropies, enthalpies, etc. by a generous use of generalized correlations and calculation methods. More data are desirable, particularly the latent heat of vaporization at atmospheric pressure and at high pressures although ΔH can be estimated by methods given in Part XIV.

Procedure for the estimation of thermodynamic properties is for the minimum possible amount of data is set forth below. It is assumed that the molecular formula of the substance in question is known and that the group contribution method of Anderson, Beyer and Watson[1] is applicable.

Step 1—From the atmospheric boiling point and critical data, prepare a graph or write an equation for the vapor pressure. A chart similar to Figure 16 (Part VIII, Refiner, February, 1948) may be used. It would be better to have at least 3 or 4 good points for approximating the vapor pressures.

Step 2—Calculate the latent heat at atmospheric pressure by the Kistiakowsky equation (Part XIV). From this value and using one of the reference line methods described in Part XIV, values of the latent heat of vaporization

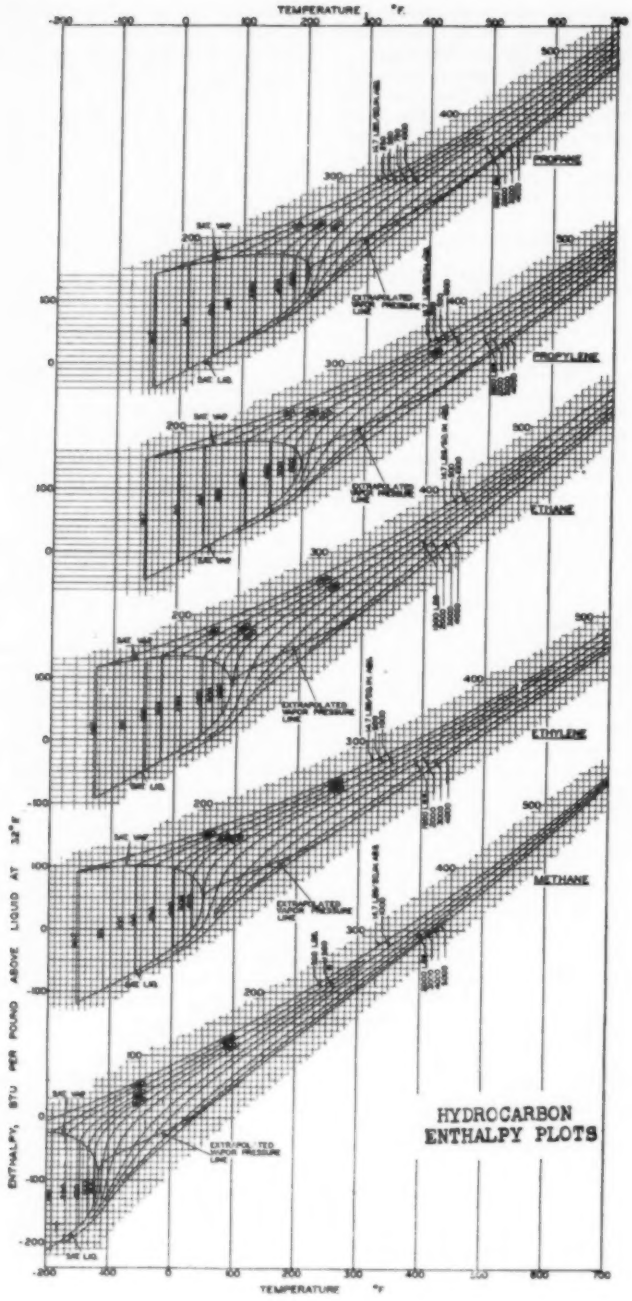


FIGURE 50

Hydrocarbon enthalpy plots prepared by W. C. Edmister and D. H. Pollock in 1937 at Whiting Research Laboratory of Standard Oil Company (Indiana).[5] Published through courtesy of Standard Oil Company (Indiana). These charts are now out of date and are no longer recommended by the authors. (See text.)

may be estimated at frequent temperature and pressure intervals up to the critical point. These results should be plotted and smoothed in similar fashion to Figure 42. The Meissner method (Part XIV) may be used to check the results at a few points.

Step 3—Obtain the ideal gas state heat capacity equation from the group contribution method of Anderson, Beyer and Watson,[1] or equivalent. In many cases there will be some observed data to use as a check.

Step 4—Integrate the heat capacity equation and calculate the effects of temperature on the entropy and enthalpy at the ideal gas state.

Step 5—Estimate the isothermal effects of pressure on the entropy and enthalpy, i.e. from the ideal gas state, by means of the generalized methods represented by Figures 48 and 49 and the appropriate equation in Part XVI (REFINER, February, 1949).

Step 6—Estimate values of volume for values of P and T, as well as the coordinates for constant volume lines from a generalized P-V-T correlation, such as Figure 19 in Part IX (REFINER, March, 1948).

Step 7—Combine the results from the above steps in the preparation of tables and charts of thermodynamic properties for the fluid.

Step 8—If heats of formation are to be incorporated in the compilation, estimate ΔH_f by means of the group contribution method and adjust the values of enthalpy accordingly to include the heat of formation.

In preparing Mollier diagrams and tables of thermodynamic properties by these steps of the *approximate* method, reduced conditions are employed in calculating volumes and the isothermal effects of pressure on the entropy and enthalpy. This is based on the assumption that the fluid obeys the law of corresponding states. Another assumption is that the group contribution method may be applied for the estimation of heat capacity and heats of formation.

If these assumptions plus the vapor pressure relationship and the latent heat reference line estimation methods are not valid, within reasonable accuracy, this *approximate* method cannot be used. Fortunately most of these simplifications may be applied to hydrocarbons.

Early Compilations

Some of the hydrocarbon thermodynamic compilations made prior to 1940, will be discussed. This year is taken because it marked the end of much pre-war activity on fundamental developments, such as thermodynamic properties. After the war the contributions to the literature on this subject have been more numerous and in most cases more comprehensive and accurate.

In 1926, Dana, Jenkins, Burdick and Timm[4] published the thermodynamic properties of saturated butane, isobutane and propane. This work included experimental data on the vapor pressures and densities of saturated vapor and liquid, specific heats of saturated liquid, and latent heats of vaporization. From these data and thermodynamic equations, the authors prepared the saturated properties tables for these three hydrocarbons, covering the range from a vapor pressure of about 7 psia. up to a temperature of 140° F. for the butanes and 125° F. for propane. The datum was saturated liquid at 0° F.

The temperature ranges of these tables are adequate for calculations on condensers and evaporators of compression refrigeration units but this is the limit of their utility. As the superheated vapor region was not included in the work, the compression calculations for the refrigeration cycle had to be made by other information.

In Perry's *Chemical Engineer's Handbook*[15] very small scale Mollier diagrams are included for methane and ethylene, the source being given as "Comm. Univ. Leiden Supplement 65" without a date.

Eucken and Berger[9] constructed and published diagrams for methane as did this author.[5,6] In both of these compilations, which were published in 1934 and 1936, the isothermal effects of pressure on the enthalpy and entropy were found by graphical differentiations and integration of the volume residual, i.e. difference between ideal and actual gas volumes. The more recent compilation by Matthews and Hurd[13] for methane is recommended in preference to these earlier ones.

In 1934, Sage and Lacey[21] presented, before the California Natural Gasoline Association, a T-S chart for propane. The published scale of this chart was small and the upper temperature is 220° F. Enthalpies and entropies were made zero for saturated liquid at 60° F.

In a discussion of the Sage-Lacey paper, Ragatz[19] presented a "Total

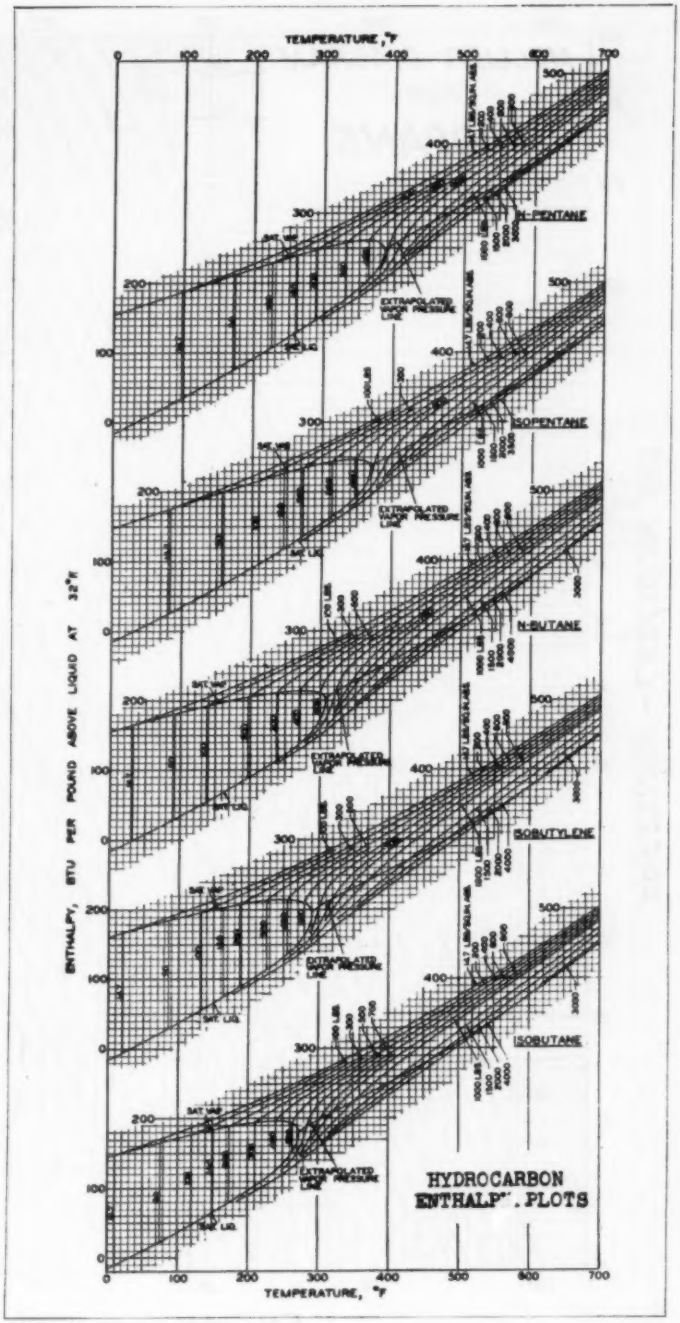


FIGURE 51

Hydrocarbon enthalpy plots prepared by W. C. Edmister and D. H. Pollock in 1937 at Whiting Research Laboratory of Standard Oil Company (Indiana).[5] Published through courtesy of Standard Oil Company (Indiana). These charts are now out of date and are no longer recommended by the authors (see text).

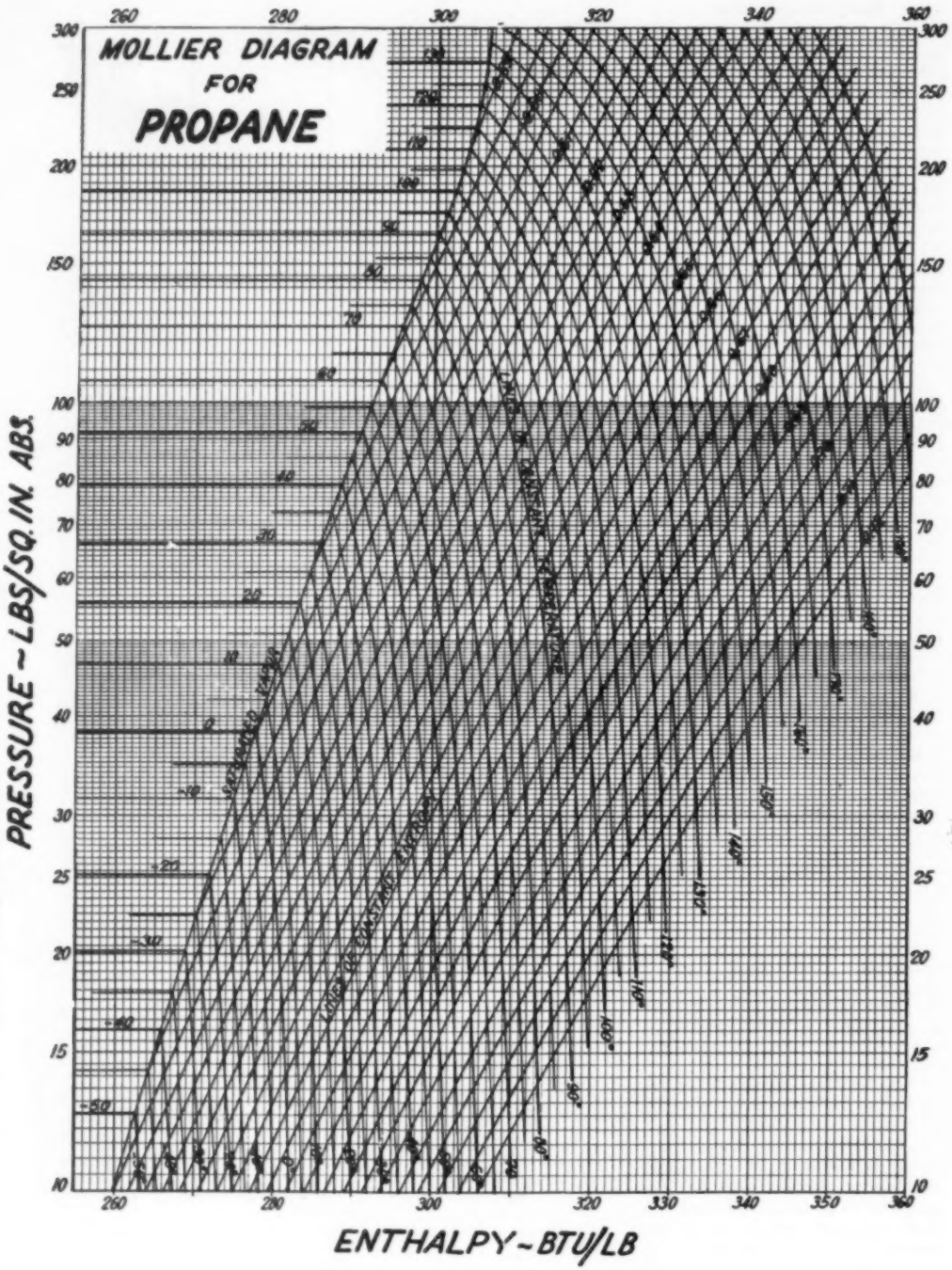


FIGURE 52

Example of Mollier chart prepared by approximate methods, using generalized correlations. Datum: Saturated liquid at —200° F. See Table 51 for enthalpies of saturated liquid and vapor. Source: Laverty and Edmister.[22]

Heat Chart" for propane which expressed enthalpies in Btu/gallon, and told how his company (Union Oil Company) had constructed a series of H-T diagrams for hydrocarbons several years earlier. This type of work was under way at many of the oil companies during the 30's.

Following the completion of the generalized thermodynamic properties of hydrocarbons, published in 1938,[7] the construction of a series of enthalpy charts for the hydrocarbons was begun by D. H. Pollock and the writer at the Whiting Research Laboratory of Standard Oil Company (Indiana). Charts for twelve hydrocarbons, from methane to n-hexane, were completed. Publication of these charts was limited to the company's technical data book and a research report when release of a manuscript prepared for presentation and publication was denied.[8] This failure to appear in any technical publication did not greatly restrict the circulation of the charts, however.

Through technical data book and report exchanges with other companies, these charts received a rather wide *company-approved* distribution. Through *other channels* the distribution of these charts continued with frequent reproductions and even in some cases the elimination of the names of the authors and their affiliation.

Today these charts are out of date. For the benefit of those who might still use these charts, some of the limitations will be pointed out.

For convenient reference, small scale reproductions of ten of these charts are reproduced in this installment as Figures 50 and 51. In the originals, the upper temperature was 1100° F. Recently published versions[11] have covered the range of 0° to 800° F. The "extrapolated vapor pressure line," shown on Figures 50 and 51, will be explained in Part XVIII.

The datum selected for these charts was liquid at 32° F., so as to be consistent with the steam tables. This presented a problem for methane whose critical was below 32° F. This reference point problem was minor compared with the problem of estimating enthalpies for the lighter components of a liquid mixture at a temperature above the critical point, however.

Both of these problems were solved by the extrapolated vapor pressure lines, which were drawn on the H-T diagrams from P-T data taken from the extrapolated portions of the vapor pressure lines on the Cox type chart. The H-vs.-T lines, thus obtained, start at the critical point and cut across the higher pressure lines, as shown in Figures 50 and 51. These lines represent a hypothetical liquid phase that has no theoretical significance. It is merely an expedient. The use of these lines will be discussed in a later installment dealing with enthalpies of hydrocarbon mixtures.

TABLE 50

Comparison of Effects of Temperature on Enthalpy in Charts of Figure 50 and 51 with Rossini Et Al.[11]

Hydrocarbon	Source	Ideal Gas Enthalpies Btu./Lb. Above Different Datums Points 100° F.	700° F.	△H	Deviation of Charts in Figure 50 and 51 Dif.	Percent
Methane	Rossini[11]	281.1	686.0	404.9	....	....
	Figure 50	135.5	545.0	409.5	+ 4.6	+1.1
Ethylene	Rossini[11]	170.5	481.3	411.2	....	....
	Figure 50	173.5	481.0	407.5	— 3.7	— 0.9
Ethane	Rossini[11]	180.6	537.8	357.2	....	....
	Figure 50	200.5	560.5	360.0	+ 2.8	+ 0.8
Propylene	Rossini[11]	146.8	455.6	308.8	....	....
	Figure 50	199.0	511.0	312.0	+ 3.2	+ 1.0
Propane	Rossini[11]	152.6	503.1	350.5	....	....
	Figure 50	194.0	530.5	336.0	—14.5	— 4.2
IsoButane	Rossini[11]	141.5	492.4	350.9	....	....
	Figure 51	179.0	503.0	324.0	—26.9	— 7.7
N-Butane	Rossini[11]	153.3	503.7	350.4	....	....
	Figure 51	190.0	514.5	324.5	—25.9	— 7.4
Isobutylene	Rossini[11]	139.7	459.9	320.2	....	....
	Figure 51	194.5	507.5	313.0	— 7.8	— 2.4
Isopentane	Rossini[11]	137.4	488.1	350.7	....	....
	Figure 51	182.5	500.0	317.5	—33.2	— 9.5
N-Pentane	Rossini[11]	150.8	499.7	348.9	....	....
	Figure 51	188.0	506.0	318.0	—30.9	— 8.8

Hydrocarbon heat capacity data available in 1937 were not adequate for the preparation of accurate enthalpy charts. The heat capacity equation used in constructing the charts, illustrated by Figures 50 and 51, was

TABLE 51

Approximate Values of Saturated Liquid and Vapor Enthalpies for Pure Hydrocarbons For Use with Figures 52, 53 and 54.

Units of Enthalpy Btu./lb. Above Saturated Liquid at —200° F.

Temp. °F.	PROPYLENE Pressure Psia.	PROPYLENE Enthalpy Sat. Liq.	PROPYLENE Enthalpy Sat. Vap.	PROPANE Pressure Psia.	PROPANE Enthalpy Sat. Liq.	PROPANE Enthalpy Sat. Vap.	n-BUTANE Pressure Psia.	n-BUTANE Enthalpy Sat. Liq.	n-BUTANE Enthalpy Sat. Vap.
—50	16.2	79.5	267.2	12.6	79.5	262.7	....	....	....
—45	18.1	82.0	268.7	14.3	82.2	264.3	....	....	....
—40	20.5	85.0	270.0	16.0	84.8	265.9	....	....	....
—35	22.5	87.5	271.2	17.8	87.1	267.2	....	....	....
—30	25.9	90.3	272.8	20.2	90.0	269.0	....	....	....
—25	28.7	92.9	274.0	22.4	92.5	270.2	....	....	....
—20	32.0	95.5	275.3	25.2	95.5	271.9	4.4	93.9	269.0
—15	35.5	98.4	276.5	28.0	98.0	273.2	5.0	96.0	270.4
—10	39.2	101.0	277.9	31.5	101.1	275.0	5.7	98.5	272.0
— 5	43.5	104.0	279.3	34.9	103.9	276.4	6.5	101.2	274.0
0	47.5	106.8	280.4	38.2	106.3	277.8	7.3	103.9	275.3
5	52.0	109.3	281.7	42.0	108.9	279.0	8.2	106.3	277.0
10	57.6	112.3	283.0	46.5	111.8	280.5	9.2	108.9	278.5
15	62.8	114.9	284.0	51.0	114.3	281.9	10.3	111.5	280.0
20	68.0	117.4	285.2	55.6	116.9	283.1	11.5	114.0	281.5
25	74.0	120.0	286.3	61.0	119.7	284.5	12.9	116.7	283.2
30	80.3	123.0	287.4	66.3	122.3	285.8	14.4	119.3	285.0
35	87.0	125.6	288.5	72.5	125.2	287.1	16.0	121.9	286.4
40	94.5	128.5	289.6	78.5	128.1	288.4	17.8	124.3	288.0
45	101.5	131.0	290.7	85.0	131.0	289.5	19.6	127.0	289.5
50	110.0	134.0	291.8	91.7	134.2	290.8	21.9	129.7	291.1
55	119.0	137.0	292.8	99.0	137.3	292.0	24.0	132.0	292.7
60	128.0	140.0	293.8	106.5	140.5	293.3	26.5	135.0	294.2
65	138.0	143.0	294.7	115.0	144.0	294.5	29.0	137.3	295.9
70	148.0	146.0	295.6	125.0	147.5	295.9	32.0	140.0	297.4
75	158.5	149.5	296.4	132.0	150.3	297.0	34.7	142.5	299.0
80	169.0	153.0	297.3	143.0	154.0	298.1	37.5	145.0	300.3
85	181.0	157.0	298.2	153.0	157.0	299.1	41.0	148.0	302.0
90	192.0	160.5	299.0	164.0	160.5	300.3	44.5	150.5	303.4
95	....	....	....	174.0	163.5	301.4	48.0	153.0	305.0
100	....	....	....	186.0	166.7	302.5	52.2	156.1	306.6
105	....	....	....	198.0	170.0	303.2	56.6	159.0	308.1
110	....	....	....	210.0	173.0	304.0	60.8	162.0	309.5
115	....	....	....	224.0	176.3	304.7	65.5	165.0	311.1
120	....	....	....	239.0	180.0	305.2	70.3	168.0	312.6
125	....	....	....	255.0	183.4	305.8	75.5	171.0	314.0
130	....	....	....	270.0	186.7	306.1	81.0	174.0	315.4
135	....	....	....	....	....	....	87.0	177.2	317.0
140	....	....	....	....	....	....	92.0	180.0	318.1
145	....	....	....	....	....	....	99.0	183.0	319.5
150	....	....	....	....	....	....	106.5	186.5	321.0
155	....	....	....	....	....	....	113.0	189.3	322.2
160	....	....	....	....	....	....	121.0	192.6	323.6
165	....	....	....	....	....	....	129.0	196.0	325.0
170	....	....	....	....	....	....	138.0	199.3	326.0
175	....	....	....	....	....	....	146.0	202.0	327.1
180	....	....	....	....	....	....	155.0	205.0	328.4
185	....	....	....	....	....	....	165.0	208.4	329.5
190	....	....	....	....	....	....	175.0	211.4	330.4

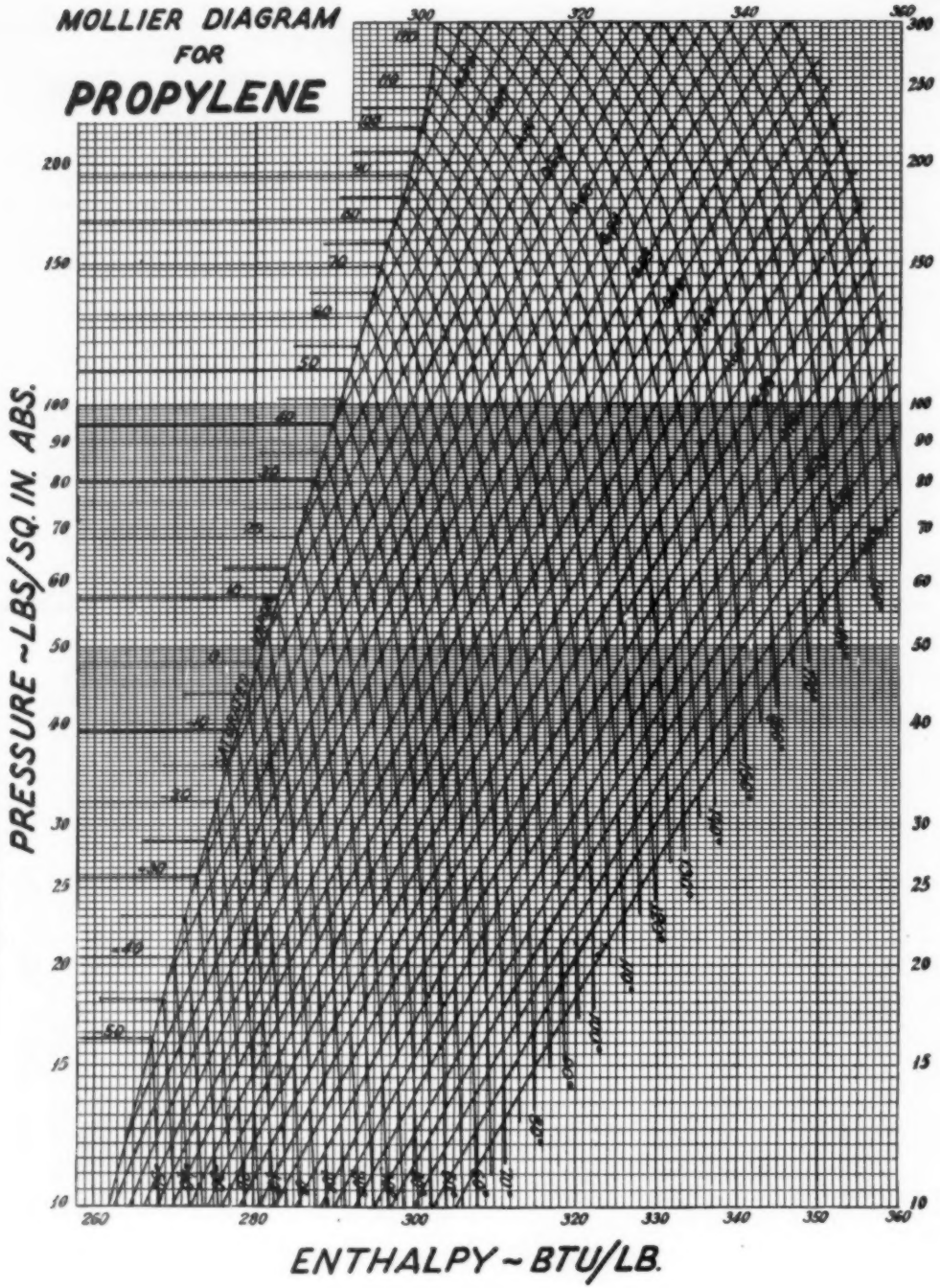


FIGURE 53

Example of Mollier chart prepared by approximate methods, using generalized correlations. Datum: Saturated liquid at —200° F. See Table 51 for enthalpies of saturated liquid and vapor. Source: Laverty and Edmister.[12]

of the form $C_p = A + BT$, where the constants A and B were given as functions of the number of carbon and hydrogen atoms. This equation, which was based on few data, was included in the author's 1938 publication of generalized thermodynamic properties.[7]

During recent years more extensive and accurate heat capacity data have become available. Rossini et al[21] have reviewed these data and selected the best values and Spencer[22] has formulated the selective values. In addition Rossini et al[21] have integrated the heat capacities and tabulated the ideal gas enthalpies. These precise values of ideal gas state enthalpies furnish a basis for checking the effect of temperature on enthalpy in the previous charts developed by Pollock and the writer in 1937.

The enthalpy changes between 100 and 700° F. for the ideal gas state for the 10 hydrocarbons shown in Figures 50 and 51 have been found from the Bureau of Standards tabulations[21] and compared with the corresponding values from Figures 50 and 51 in Table 50.

At Atmospheric Pressure

It will be noted that the values of H from these two sources are of different magnitudes even though the ΔH values are reasonably close in some cases. This is due to the fact that the two compilations use different reference points: namely, ideal gas at —459.7° F. for Bureau of Standards values and saturated (or hypothetical) liquid for Figures 50 and 51.

It should also be pointed out that the values from Figures 50 and 51 are at atmospheric pressure rather than the ideal gas state. This does not invalidate the comparison, however, as there is very little difference between the enthalpy values at 14.7 and 0 psia. for these fluids.

From the comparison in Table 50, it can be seen that the change in enthalpy with temperature shown on Figures 50 and 51 is not correct and that this difference amounts to as much as 33 Btu./lb. in a 350 Btu./lb. enthalpy change between 100 and 700° F., i.e. almost 10 percent low.

The effects of pressure on the enthalpy for constructing the diagrams in Figures 50 and 51 was found by generalized correlations, which were discussed in Part XVI. As far as pressure is concerned, these 1937 enthalpy charts are of the accuracy demonstrated in the comparisons given in Part XVI. While accuracy in the changes of enthalpy with pressure are important, accuracy in the changes with temperature are more important. In most hydrocarbon processes, enthalpy effects due to pressure changes are small compared to enthalpy changes due to temperature changes.

For those possessing and using the large scale hydrocarbon enthalpy diagrams represented by Figures 50 and 51, it is recommended that they at least revise the temperature effect on enthalpy portion. This should be done by using the Bureau of Standards data and shifting the pressure parameter up or down, as required. The resulting charts would be more accurate than the existing charts but would still be *approximate* diagrams.

Recent Compilations

Some of the recent compilations of hydrocarbon thermodynamic properties, particularly two other appearances in the literature of charts prepared by the writer, will be discussed.

In 1940, the writer prepared several Mollier diagrams of light hydrocarbons, by the *approximate* method described above, for use in the defense of a patent infringement suit brought against Standard Oil Company (Indiana) on the use of propane as a refrigerant. These charts were used to make comparisons between hydrocarbons and ammonia.

With the limited time available, it was only possible to construct the portions of the charts of interest in making refrigeration calculations and to make a few minor improvements in the previous work done in developing the charts shown in Figures 50 and 51. These were a) changing the reference point to saturated liquid at —200° F., and b) using better heat capacity data.

These charts, which were later included in an article by Laverty and Edmister,[12] included propane, propylene, n-butane, a plant propane mixture, a propane-butane mixture, a propane-propylene mixture and an ethane-butane mixture. The methane diagram included with these charts was *not* prepared by the writer, but was furnished by Laverty. Figures 52, 53 and 54 are the saturated and superheated vapor sections of pure component charts. The saturated liquid portions have been cut off and the values listed in Table 51 to save space. The corresponding diagrams for the mixtures will be presented and discussed in a later installment.

In the *Oil and Gas Journal* publication of this article[12] only the mixture charts were printed, the diagrams for the three pure hydrocarbons being omitted. However, Clark Brothers Company reprinted the article and included all of the diagrams. This reprint was distributed rather widely. In these original publications the saturated liquid curves were included but the tabulation of these values is as convenient a method of presenting the charts.

These Mollier diagrams are presented as examples of the results that can be obtained in a hurry by the *approximate* method using generalized correlations. They are not offered as precise or permanent compilations. A few comparisons with more accurate charts will be made below to indicate their accuracy, however.

The third edition (1942) of *Handbook—Butane-Propane Gases*[20] contained the diagrams for propane and butane given here as Figures 52 and 54. Along with these diagrams were tables of the saturated liquid and vapor properties. In addition to the vapor pressures and enthalpies given in Table 51, the tables given in the Butane-Propane Handbook contain densities from another source.

In 1943 (with revision in 1946), Stearns and George[24] published thermodynamic properties of propane. Although this compilation is more complete and more accurate than the propane properties given in Table 51 and Figure 52, it can not be considered as a thorough and rigorous job for the superheated vapor region because the best P-V-T data and equation of state available were not used.

A few spot calculations have been made on propane, using the data of Stearns and George[24] and Table 51 and Figure 52, to show how the two compilations compare. These results follow:

Latent Heat of Vaporization	Stearns and George[24]	Figure 52 and Table 51
at —40° F.	182.7 Btu./lb.	181.1 Btu./lb.
at +90° F.	140.1 Btu./lb.	139.8 Btu./lb.

Isentropic Change T_1	P_1	P_2	Stearns and George[24] T_2 °F.	ΔH Btu./lb.	Figure 52 and Table 51 T_2 °F.	ΔH Btu./lb.
80° F.	60 psia.	300 psia.	200	38.6	200	38.4
109° F.	40 psia.	160 psia.	200	35.4	203	36.0

Isenthalpic Change T_1	P_1	P_2	Stearns and George[24] T_2 °F.	Figure 52 and Table 51 T_2 °F.
140° F.	200 psia.	60 psia.	115	111
200° F.	250 psia.	80 psia.	176	175

This comparison indicates fairly good agreement. Neither compilation is extensive enough for much precision in making readings, however.

A similar comparison will be made for n-butane, using the more recent

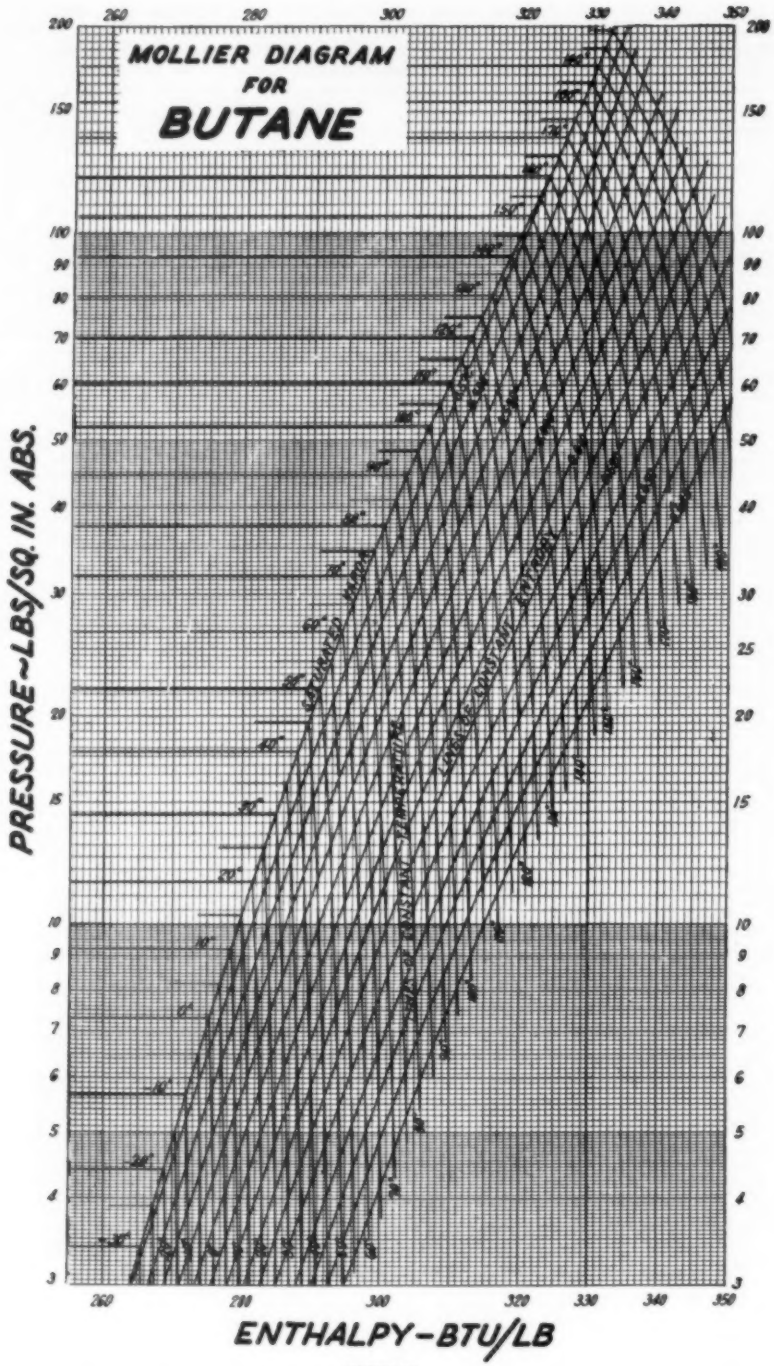


FIGURE 54

Example of Mollier chart prepared by approximate methods, using generalized correlations. Datum: Saturated liquid at —200° F. See Table 51 for enthalpies of saturated liquid and vapor. Source: Laverty and Edmister.[32]

extensive and precise correlations of Prengle, Greenhaus and York,[18] which was discussed in the previous installment. This comparison is necessarily limited to the low pressures of Figure 54. The results follow:

Latent Heat of Vaporization	Prengle et al.[18]	Figure 54 and Table 51
at 40° F.	163.8	163.7
at 150° F.	135.3	134.5

Isentropic Change T_1	P_1	P_2	T_2	ΔH	T_2	ΔH
120° F.	2 atm.	8 atm.	194° F.	26.0 Btu./lb.	201° F.	27 Btu./lb.
80° F.	2 atm.	6 atm.	140° F.	20.6 Btu./lb.	145° F.	20 Btu./lb.

Isenthalpic Change T_1	P_1	P_2	T_2	T_2
180° F.	8 atm.	4 atm.	162° F.	163° F.

This comparison is not so favorable to Figure 54 as far as temperature changes in the superheated vapor region are concerned.

The above comparisons indicate the reliability of the *approximate* method of constructing Mollier diagrams. These comparisons are not conclusive because of the limited range covered.

In 1946, Hanson[10] published the thermodynamic properties of saturated liquids and vapors of propane, propylene, isobutane, isobutylene and n-butane. In making this compilation, Hanson used the writers generalized correlation in computing the entropies and enthalpies of saturated vapor from the values for the ideal gas state at the same temperature. This appears to be the only weakness in these tabulations. As pointed out by Prengle et al.,[18] it was not necessary to use this generalized method for n-butane because there are accurate P-V-T data available for this substance. Since Hanson used the same procedure for all five hydrocarbons his results should be consistent, however.

In addition to those other recent U. S. compilations of thermodynamic properties for hydrocarbons of note,[2, 13, 14, 25] similar work has been under way in Germany, as evidenced by the recent Mollier diagrams prepared by Plank and co-worker[16, 17] at the Kaltechnisches Institut in Karlsruhe. The ranges of the charts are suitable for refrigeration calculations, the upper pressure for the propane chart being 18 atmospheres and for the ethane chart, 30 atmospheres.

Sample Calculations

As an illustration of the *approximate* method, employing the generalized correlations, points will be computed for propane. These points will illustrate the procedure for calculating the effects of temperature and pressure on the entropy and enthalpy and also the calculation of latent heats.

Problem: The problem used in this example is to find the differences in H and S between saturated liquid at 100° F. and superheated vapor at 300° F. and 200 psia. The path followed will be a) vaporization from saturated liquid at 100° F. and 186 psia. (the vapor pressure) to saturated vapor at same conditions; b) expansion at constant temperature from saturated vapor to ideal gas vapor; c) heating at ideal gas state from 100 to 300° F., and d) isothermal compression to 200 psia. at 300° F.

These calculations need not be made in this order but the results must be combined in this order, taking some point as the zero reference. Effect of temperature on the enthalpy of superheated vapor is always computed at the ideal gas state. The effect of temperature on the enthalpy and entropy of saturated vapor and liquid is usually obtained via the effect of temperature on these same properties in the ideal gas state.

Latent Heat of Vaporization—For this example the latent heat of vaporization will be found by Kistiakowsky's and Watson's methods, equations 284 and 288, and then checked by the Meissner chart, Figure 45 (all in Part XIV).

By equation 284 the latent heat at the atmospheric boiling point of —44° F. (231° K.)

$$\Delta h = 231(8.75 + 4.571 \log 231)\frac{1.8}{44.1} = 184.5 \text{ Btu./lb.}$$

By equation 288 and this value of the latent heat at —44° F., the value at 100° F. is found as follows

$$T_r' = \frac{416}{666} = 0.625$$

$$T_r = 0.84$$

$$\Delta h = 184.5\left(\frac{1-0.84}{1-0.625}\right)^{0.38} = 133 \text{ Btu./lb.}$$

By equation 287 the atmospheric pressure value of Δh (i.e. 184.5 Btu./lb.) is corrected to 100° F. as follows: From Figure 43 values of the entropy functions are 19.5 and 10.5 respectively for T_r values of 0.625 and 0.84.

$$\Delta h = \left(\frac{10.5}{19.5}\right)\left(\frac{0.84}{0.625}\right)184.5 = 133.6 \text{ Btu./lb.}$$

From Figure 45, the latent heat of vaporization at 100° F. and 186 psia. is found by making a reading at $T_r = 0.84$ (100° F.) and $P_r = 0.30$ (186 psia.), obtaining $\Delta H_v/T_c = 9.0$, from which

$$\Delta h = 9.0\left(\frac{666}{44.1}\right) = 136.2 \text{ Btu./lb.}$$

Hanson[10] gave 183.1 Btu./lb. at —44° F. and 136.2 Btu./lb. at 100° F., which would indicate that equations 287 and 288 are not very precise methods of estimating latent heats from the atmospheric pressure values. The value of 136.2 Btu./lb. will be used. The entropy of vaporization corresponding is

$$\Delta S_v = \frac{136.2}{560} = 0.244 \text{ Btu./lb. °R.}$$

Effect of Temperature—For these computations the equation developed by Spencer[23] for Cp° of propane will be used. This equation is based on the selected data of Rossini et al.[21] and is

$$Cp^\circ = 2.41 + 0.057195T - 0.000017533T^2$$

This equation is for the range 298.1° K. to 1500° K. with T in °K and Cp° as molar heat capacity. The coefficients of T and T^2 must be divided by 1.8 if T is to be expressed in °R.

Effect of Temperature on Enthalpy—The difference in enthalpy for propane in the ideal gas state between 100° F. and 300° F. is found as follows

$$H^\circ_{300^\circ} - H^\circ_{100^\circ} = \int_{100}^{300} Cp^\circ dT =$$

$$2.41(760 - 560) +$$

$$\frac{0.057195}{2 \times 1.8}(760^2 - 560^2) -$$

$$\frac{0.000017533}{3 \times 1.8}(760^3 - 560^3) =$$

$$482 + 4180 - 850 =$$

3812 Btu./lb. mol, or 86.5 Btu./lb.

Effect of Temperature on Entropy—The difference in the ideal gas state entropies between 100° and 300° F. is found as follows

$$S^\circ_{300^\circ} - S^\circ_{100^\circ} = \int_{100}^{300} \frac{Cp^\circ}{T} dT =$$

$$(2.41)(2.3)\log_{10}\frac{760}{560} +$$

$$\frac{0.057195}{1.8}(760 - 560) -$$

$$\frac{0.000017533}{2 \times 1.8}(760^2 - 560^2) =$$

$$0.737 + 6.35 - 1.28 =$$

5.807 Btu./lb. mol°R or 0.132 Btu./lb.°R

Effects of Pressure on Enthalpy—The isothermal difference (at 100°

TABLE 52

Summary of Sample Calculations of Enthalpy and Entropy Values for Propane.

POINT	Temp. °F.	Pressure, Psia.	State	Enthalpy Btu./Lb.		Entropy Btu./Lb./°R	
				△H	H	△S	S
1	100	186	Sat. Liq.		0		0
				+136.2		+0.244	
2	100	186	Sat. Vap.		136.2		0.244
				+ 21.2		+0.264	
3	100	0	Ideal Gas		157.4		0.508
				+ 86.5		+0.132	
4	300	0	Ideal Gas		243.9		0.640
				— 9.1		—0.246	
5	300	200	Superheated Gas	.....	234.8	.....	0.394

F.) between the enthalpy at the 186 psia. saturated vapor pressure and the ideal gas state of zero pressure is found from the generalized correlation, Figure 48, Part XVI.

$$T_r = \frac{460 + 100}{460 + 206} = 0.84$$

$$P_r = \frac{186}{618} = 0.30$$

From Figure 48 the following reading is made for these reduced conditions

$$\frac{-\Delta H}{Tc} = 1.4$$

$$H^\circ_{100^\circ} - H^{186\text{ lb.}}_{100^\circ\text{ F.}} = (1.4)(666) =$$

933 Btu./lb. Mol, or 21.2 Btu./lb.

The isothermal difference (at 300° F.) between the enthalpy at 200 psia. and the ideal gas state of zero pressure is also found from Figure 48

$$T_r = \frac{460 + 300}{666} = 1.14$$

$$P_r = \frac{200}{618} = 0.324$$

From Figure 48 the following reading is made for these reduced conditions

$$\frac{-\Delta H}{Tc} = 0.6$$

$$H^\circ_{300} - H^{200\text{ lb.}}_{300^\circ} = (0.6)(666) =$$

400 Btu./lb. mol, or 9.1 Btu./lb.

Effect of Pressure on Entropy—The isothermal effect of pressure will be found by means of the residual entropies in Figure 49 plus the RlnP term down to 1.0 psia. At 186 psia. and 100° F. these calculations are as follows:

From Figure 49, at $T_r = 0.84$ and $P_r = 0.30$, $-\Delta S' = 1.25$. At 186 psia. with 1.0 psia. base, $RlnP = (1.987)(2.3)(\log_{10} 186) = 10.4$. Combining these two entropy corrections,

$$S^\circ_{100} - S^{186\text{ lb.}}_{100^\circ} = 1.25 + 10.4 = 11.65$$

Btu./lb. mol °R, or 0.264 Btu./lb. °R.

At 200 psia. and 300° F. these calculations are as follows:

From Figure 49, at $T_r = 1.14$ and $P_r = 0.324$, $-\Delta S' = 0.35$. At 200 psia. with 1.0 psia. base, $RlnP = (1.987)(2.3)(\log_{10} 200) = 10.5$. Combining these two entropy corrections,

$$S^\circ_{300^\circ} - S^{200\text{ lb.}}_{300^\circ} = 0.35 + 10.5 =$$

10.85 Btu./lb. mol °R, or 0.246 Btu./lb. °R

At this point it should be recalled that the base pressure for calculating the RlnP term may be 10 psia. just as well, providing this pressure is used in all calculations for the pressure corrections on the entropy.

Results—The above are the individual steps in the computation of points for the Mollier diagram of propane. With the results of these calculations, the summary in Table 52 is prepared, calling the values of H and S zero for saturated liquid at 100° F.

If volumes are required, they can be estimated from a compressibility factor plot. If the heat of formation is desired it can be included by adding the proper number with an appropriate datum.

Since Rossini et al.[21] have tabulated enthalpies and entropies for the ideal gas state it is not necessary to perform the integrations for the effects of temperature, illustrated here. Enthalpies above the elements at —459.7° F. may be obtained from the Bureau of Standards tabulations by adding the heat of formation values at absolute zero to the enthalpy values at other temperatures.

Conclusions

For hydrocarbons, the effect of temperature on enthalpy and entropy should be taken from the Bureau of Standards tables by Rossini et al.[21] These tables also have heats of formation and many other useful properties. For components not covered in these tables, group contributions methods[1] may be used as approximations.

The effects of pressure should be computed by rigorous equations of state and/or graphical methods where the data and time available permit. Generalized methods may be used for rapid approximations.

The charts presented in this installment illustrate the results of the procedures and methods described.

In the next installment, enthalpies of hydrocarbon mixtures will be discussed.

End of Part XVII. Part XVIII will appear in the April issue.

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O. C. BLADE

High-Sulfur Crude Oils—

Trends in Supply

II. U. S. DATA OF 1945-47

O. C. BLADE
Petroleum Chemist, U. S. Bureau of Mines, Bartlesville, Oklahoma

IN 1947 Smith and Blade prepared a study on the trends of supply of high-sulfur crude oils in the United States. This was presented at the November 1947 meeting of the American Petroleum Institute and published in the proceedings[1] of that organization. It was also published elsewhere in slightly abbreviated form.[2]

At the time the paper was prepared the 1946 data were not complete, and subsequent study has shown that a statistically incorrect factor in certain calculations was used for the data for that year. Consequently the data for 1945, 1946, and 1947 have been studied, and the results are given in this report.

Production data for approximately 850 oil fields and areas in the United States that produced 100,000 barrels or more during each of the years 1945 and 1946 and 2500 barrels per day or more for the year 1947 were compiled. The data, recorded as thousands of barrels for the year, were taken from the Minerals Yearbook 1946[3] and the AIME[4] volumes on production statistics for the three years. The figures were tabulated by fields in nine geographic districts and five sulfur-content groups, as in the original paper.

A tabulation of the production by districts and groups is in Table 1 for each of the three years.

Study of the nation's total crude oil production for those years indicates a general increase in all groups. The most significant changes from 1945 to 1947, considering the entire country, appear to be in the two low-sulfur groups (less than 0.5 percent), where increases of approximately 35 and 40 million barrels, respectively, occurred, and in the highest sulfur group (more than 2 percent), which increased 60 million barrels.

These changes appear to be caused largely by increased production of low-sulfur crude oils from the California, Gulf Coast, West Texas-New Mexico, and Southeastern districts, and by increases in production of crude oil of more than 2 percent sulfur from the Rocky Mountain, West Texas-New Mexico, Mid-Continent, and Southeastern districts. Figure 1 shows the production for each group for the United States in thousands of barrels.

In general, the increase in production of crude oils having more than 0.5 percent sulfur content has been gradual but definite since 1935. The proportion of high to low-sulfur crude oil production has increased from 0.49 in 1940 to 0.54 in 1945 and 1946

TABLE 1
Crude oil production, millions of barrels, by sulfur content, 1945-47
(1947 figures subject to revision)

DISTRICT	Percent U. S.	Year	0-0.25%S	0.26-0.50%S	0.51-1.0%S	1.01-2%S	>2%S	Total
California	19.05	1945	20.1	65.1	102.1	117.1	22.1	326.5
	18.18	1946	27.9	58.3	86.5	122.4	20.0	315.1
	18.06	1947	25.0	71.4	84.8	131.6	23.8	336.6
Rocky Mountain	2.93	1945	18.3	.4	8.4	8.2	14.8	50.1
	3.44	1946	14.2	.7	14.9	9.9	19.9	59.6
	3.94	1947	13.4	.....	19.7	16.9	19.6	69.6
Gulf Coast	23.85	1945	374.9	33.4	.5	.....	.....	408.8
	23.65	1946	385.6	23.5	.8	.....	.....	409.9
	24.18	1947	420.0	28.9	1.8	.....	.....	450.7
West Texas-New Mexico	12.40	1945	12.5	10.3	19.5	152.1	18.2	212.6
	13.19	1946	27.5	16.9	21.3	144.8	18.2	228.7
	14.18	1947	40.5	25.8	23.4	122.4	50.3	262.4
Mid-Continent	33.03	1945	148.2	306.3	58.6	21.0	31.8	565.9
	32.42	1946	144.7	296.2	63.6	21.5	36.0	562.0
	31.44	1947	109.3	333.7	58.3	39.9	44.7	585.9
Illinois, Indiana, W. Kentucky	5.18	1945	60.8	27.9	.1	.....	.....	88.8
	5.26	1946	61.0	30.1	.1	.....	.....	91.2
	4.32	1947	54.7	25.7	.....	.....	.....	80.4
Michigan-Lima	1.02	1945	2.1	6.9	8.5	.....	.....	17.5
	1.00	1946	1.6	7.1	8.5	.....	.....	17.3
	.88	1947	1.7	4.9	9.8	.....	.....	16.4
Southeastern	1.13	1945	2.4	.....	11.5	.....	5.4	19.3
	1.42	1946	4.9	.1	11.1	.....	8.6	24.6
	1.92	1947	8.9	.....	13.2	.....	13.7	35.8
Appalachian	1.41	1945	24.2	.....	.....	.....	.....	24.2
	1.44	1946	25.0	.....	.....	.....	.....	25.0
	1.38	1947	25.6	.....	.....	.....	.....	25.6
Total United States	100.00	1945	663.5	450.3	209.2	298.4	92.3	1,713.7
	100.00	1946	692.4	432.9	206.8	298.6	102.7	1,733.4
	100.00	1947	699.1	490.4	211.0	310.8	152.1	1,863.4

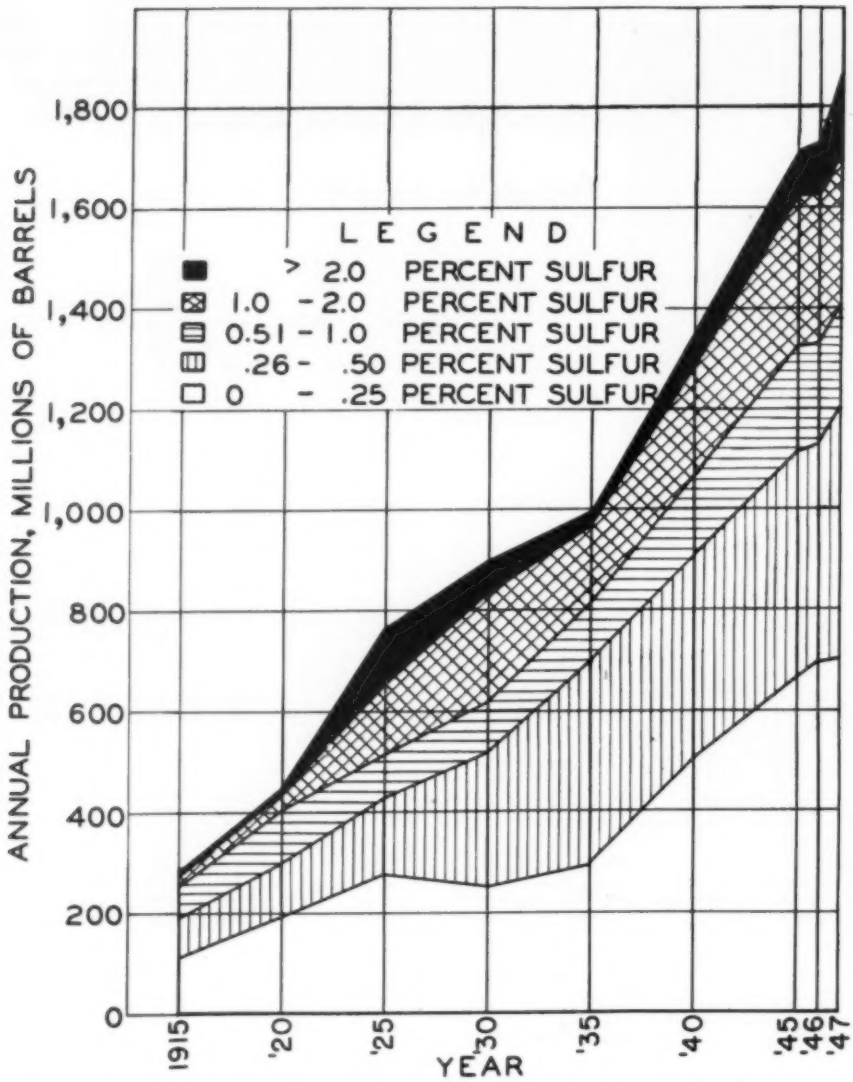

Figure 1—Crude Oil Production for Intervals from 1915 Grouped According to Sulfur Content, United States.

to 0.57 in 1947. Table 2 shows the total production figures in the two divisions and their ratios for the years studied.

TABLE 2

YEAR	High-Sulfur (Over 0.5 Percent S)		Low-Sulfur (0.5 Percent S)		Ratio of High-Sulfur to Low-Sulfur
	Millions of Barrels	Percent	Millions of Barrels	Percent	
1915	95	34	186	66	0.51
1920	144	33	299	67	.48
1925	339	44	425	56	.80
1930	382	43	516	57	.74
1935	295	30	702	70	.42
1940	444	33	909	67	.49
1945	600	35	1,114	65	.54
1946	608	35	1,125	65	.54
1947*	674	36	1,190	64	.57

* Subject to revision.

NOTE

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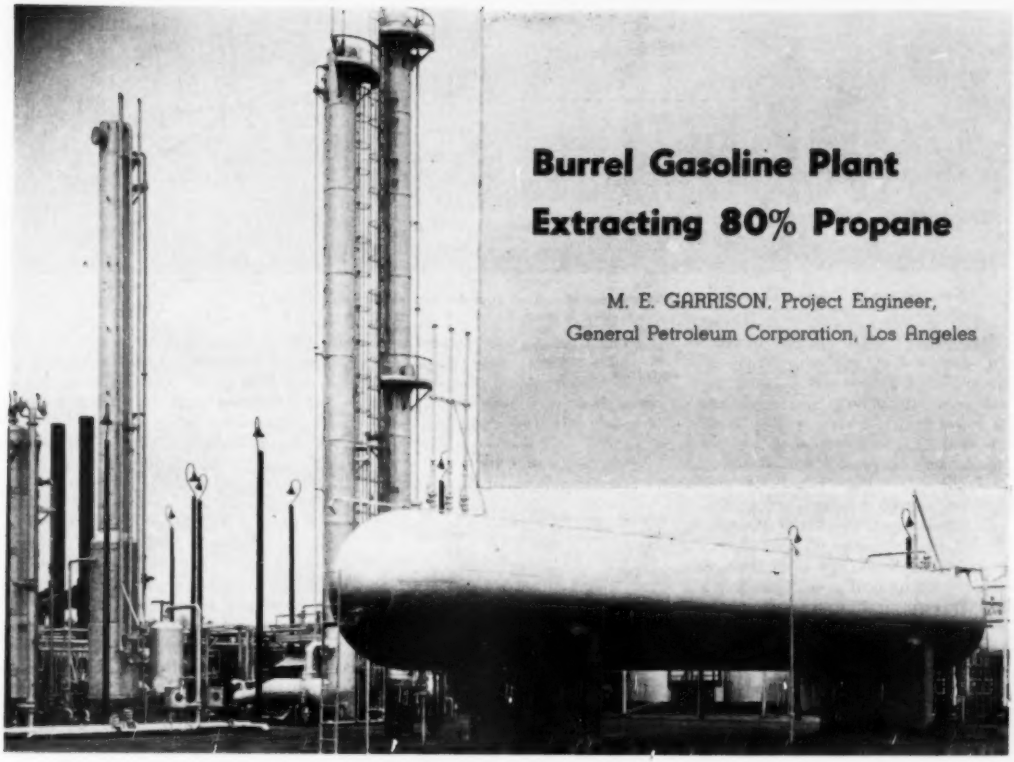


Burrel Gasoline Plant Extracting 80% Propane

M. E. GARRISON, Project Engineer,
General Petroleum Corporation, Los Angeles

Figure 1. Propane Storage and LPG Fractionating Equipment at General Petroleum Corporation's Burrel Gasoline Plant.

A NATURAL gasoline plant which has achieved an 80 percent extraction level of propane potential and a 90 percent extraction level of isobutane potential has been operated by the General Petroleum Corporation in the Fresno area of California since April, 1946.

This high extraction efficiency has been particularly desirable since the demand for propane in the area which the plant is located has been growing at a remarkable rate.

Notable in the design and construction the "Burrel Gasoline Plant," is believed to be the largest ever installed in a natural gasoline plant in California.

The plant was designed with a capacity of 30,000 mcf. per day of wet gas which was found to be available in the field at three pressure levels: 50 psig., 150 psig., and 450 psig.

Purposes of the plant 1) to deliver dry gas at 440 psig. to a gas company; 2) to deliver dry gas at from 500 to 600 psig. to another gas company pipe line system at a controlled maximum temperature 5° above wet bulb, and a minimum temperature of 60° F.; 3) to make possible the extraction and retention of 85 percent of the isobutane content of the wet gas, and at the same time extract up to 70 percent of the propane content of the wet gas.

Actual extraction in the 35 months the plant has been in operation has exceeded 80 percent of propane potential and 95 percent of the isobutane.

A fourth aim of the designers was to make possible selective absorption within the absorption plant to a point where extraction efficiency can be controlled with a minimum quantity of recycled gas and with minimum plant fuel consumption. To accomplish this it was calculated that the most economical main absorption pressure would be 450 psig.

The approximate average isobutane-plus-gasoline content of the combined wet gas was 1.3 gpm. and the 20 percent rectified content 0.6 gpm.

Wet gas is collected from the Helm field, northwest from the plant; the Lanare field, south; and the Riverdale field south and east.

From the Helm field a high-pressure wet gas gathering line has been laid, approximately eight miles in length, to deliver wet gas at from 440 to 450 psig. at the plant. A low-pressure wet gas line parallels the high-pressure line to deliver wet gas at the plant at 50 psig. This permits two-stage gas trap operation for the separation of the oil and gas as it flows from the producing well. In general all of the wet gas lines are laid to grade sloping toward the gasoline plant. The 50 psig. wet gas line carries the condensate for both lines through two sets of drip stations located in the field, and one set located at the entrance to the gasoline plant. Vertical drip pots were installed with level and pressure controls, in order to raise the condensate to successively higher elevation.

On the 450 psig. line, three heater installations have been installed to minimize the possibility of the formation of hydrates during the winter months. These are designed to maintain the gas temperature above 60° F.

A 4-inch dry gas line parallels the Helm wet gas gathering line for approximately 3¼ miles west from the

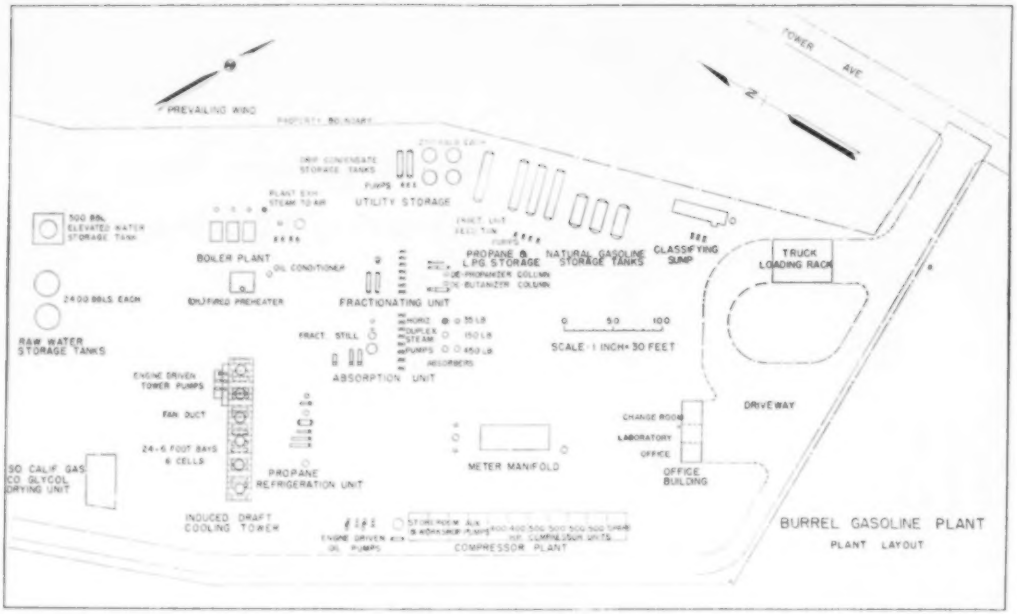


Figure 2. Burrel Gasoline Plant Layout.

plant, where it ties to the Amerada Petroleum and to the General Petroleum Corporation dry gas fuel systems. The dry gas pressure on this line is approximately 140 psig. pressure.

From the Riverdale oil field was laid an intermediate pressure wet gas gathering line approximately 7½ miles long, to deliver gas at from 145 to 160 psig. pressure at the plant. To collect the low-pressure wet gas below 150 psig. pressure, two gas-engine-driven field compressor booster stations were installed. A low-pressure wet gas gathering pipe line parallels the 150 psig. pressure line for approximately 2¾ miles on the Riverdale end of the system. This line delivers wet gas at from 20 to 50 psig. pressure to the field booster compressor

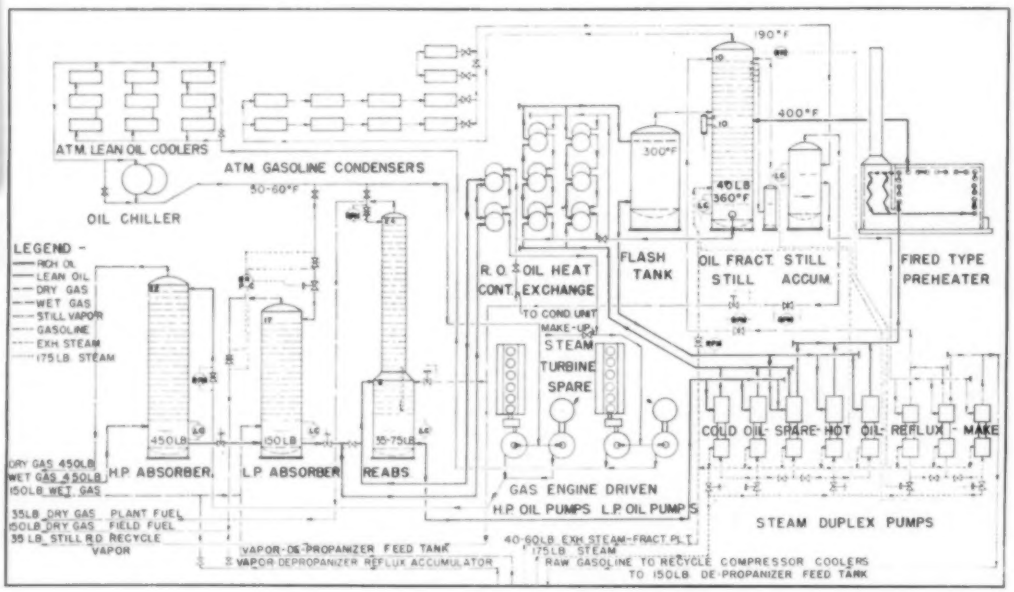


Figure 3. Absorption Unit Flow Sheet of General Petroleum's Burrel Plant.

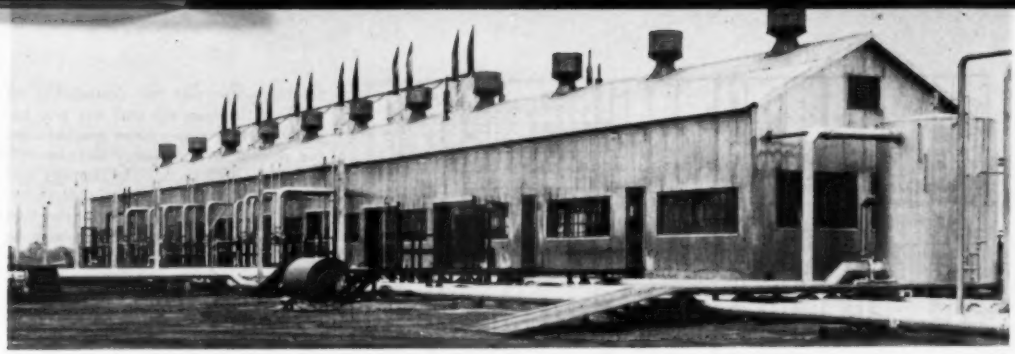


Figure 4. Compression and Auxiliary Equipment Building at Burrel Plant.

stations. The suction pressure to these field compressors is regulated so as to not exceed 30 psig. These field compressors boost or compress this gas from 30 to 150 psig. pressure and deliver it into the intermediate pressure gas line to the gasoline plant.

Two additional field compressor stations were later installed. One of these compresses wet gas and tank vapors from 5-inch vacuum to 150 psig. pressure and the other compresses tank vapors from 5 to 10-inch vacuum and delivers them into the 30 psig. low-pressure wet gas line to the field booster compressors.

In general the 150 psig. intermediate pressure line slopes toward the plant and the low-pressure line slopes toward the field booster compressor stations. Vertical drip pot installations are located at each field compressor station in conjunction with intake wet gas scrubbers. These vertical drip pot installations are also located at the Murphy Slough crossing and at the entrance to the gasoline plant.

Also paralleling the 150 psig. intermediate wet gas line was laid a 4-inch dry gas line extending from the plant approximately 5 miles easterly. This line delivers dry gas to the Riverdale field. The dry gas pressure on this line at the gasoline plant is approximately 140 psig.

A wet gas collection line approximately 4½ miles long was laid from the Lanare field to the plant. It originally tied into the intermediate 150 psi. wet gas line from Riverdale at the plant entrance. Due to pressure decline in this field this line was later connected into the 50 psi. pressure wet gas line from the Helm field at the plant boundary.

In general the wet gas gathering system, due to the long lengths of pipe line involved, was designed so that when future pressure declines had to be met, field booster compressors could be installed to maintain pressure and capacity.

The field booster compressor units consist of 90 horsepower gas engines V-belt driving type heavy duty twin-cylinder compressor units. The compressor units were second hand. A thermo-syphon oil compressor jacket cooling system with a vertical surge tank was installed for cooling the compressor jackets.

Gasoline Plant Design

There are four gas pressure levels which may be considered for the absorption of the wet gas. At the 600-psi. level only two-thirds of the dry gas had to be compressed. Thus it can be canculated that the most economical pressure for absorption would be 450 psi. The next consideration is the arrangement or flow necessary to obtain selective absorption for the isobutane and propane content of the wet gas. Pressure of 150 psi was decided as the most desirable fuel gas pressure for delivery to the field. On this basis a flow sheet was arranged. See Figure 3.

At the 150-psi. level all the rich oil from the 450 psi. absorber is flashed in the base of the 150-psi. absorber. Additional wet gas is added to the 150-psi. absorber as required to furnish field fuel and plant fuel make-up. In addition, in order to make maximum propane yield the de-propanizer vent gas vapors and the de-propanizer feed tank vapor are returned to the 150-psi. absorber.

The rich oil then flows from the base of the 150-psi. absorber through heat exchangers, where it can be heated to 120° to 180° F. as desired. The heating medium is hot lean oil from the still. The hot rich oil passes from these heat exchangers into the base of a 35-psi. re-absorber, where it is flashed. Selective absorption is made possible by the control of the oil gas ratios on the 450-psi., 150-psi. and 35-psi. absorbers and by the control of the rich oil temperature to the 35-psi. absorber. In order to accomplish this control, it can be observed that the raw gasoline still vapors are compressed from 30-35 psi. pressure to 150-160 psi. pressure and the raw gasoline make, excess above reflux, is pumped into these compressed vapors in the coolers in the cooling tower on their way to the de-propanizer feed tank. This flow eliminates the recycle vapor build-up commonly found in the older plants in operation in California.

Further consideration in the design

Figure 5. Meter Manifold and Process Equipment.

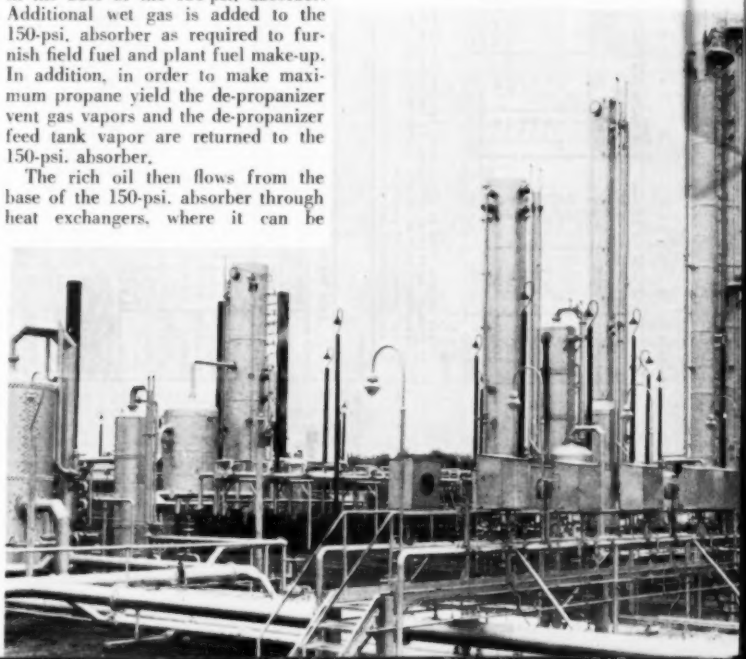


Figure 6. Burrel Gasoline Plant—Material Process Flow Calculations.

at this point was the desirability of chilling the lean oil and wet gas, because of the temperature specification for residue dry gas sales at from 60° to 70° F. both during the summer and winter months. At this point, however, the only interest is in the fact that oil and gas temperatures may be selected for design regardless of seasonal atmospheric cooling conditions.

Material Balances Calculated

In order to design properly for the flow sheet (Figure 3), an assumption of the gas quantities to be handled had to be made from the field data. Also composite analysis of the wet gas had to be obtained from very preliminary laboratory data. Material balances and equilibriums were next calculated so that equipment could be properly selected for installation. This data can be observed in Figure 6. In Figure 7 is plotted the daily volume of methane, ethane, and propane vented at temperatures from 120° to 180° F. for a 1.3 iso-butane absorption factor throughout the three absorption steps. From this data it can be observed that the optimum temperature for the extraction of iso-butane is in the neighborhood of 160° F. Also it can be observed that for maximum propane extraction the temperature should be in the neighborhood of 120° F. These temperatures refer to the flash temperature of the rich oil in the base of the 35-psi. re-absorber. However, the propane extraction is dependent on the lean oil temperature to the absorbers and the oil gas ratio selected which sums up into the selection of a proper propane factor for the most economical recovery. In Figure 8 has been plotted curves of different lean oil temperatures with re-absorber flash temperatures plotted as ordinates and oil gas ratio requirements plotted as abscissas.

Elimination of the light hydrocarbon fractions of methane, ethane and propane, from the rich oil in the 35-psi. re-absorber eliminates these vapors from contamination in the raw gasoline and performs the function of partial de-ethanization by means of selective absorption. These light fractions once condensed in the raw gasoline stream, in the past, led to high recycle loads and considerable recompression in order to prevent gasoline losses. The method used in the design of the Burrel gasoline plant minimizes these vapors from the rich oil at the expense of only a small amount of additional oil circulation rate.

From the data in Figure 6 and the proposed flow sheet Figure 3 make it

Columns	38	39	40	46	47	48	49	50	51	52	53	54	55	56	57	58	59
										38 plus 49		Based on Cols. 51 and 52					

Component Material	1145 Absorber Analysis - Lean Oil 58°API Grav.- 185 Molecular Weight- Rich Oil Flash 180°F 14.9 Vapor Equivalent-Iso-butane Equilib. at 70°F			DRY GAS-Fuel			ABSORBED			COMPOSITE Rich Oil			FLASH OF RICH OIL IN FLASH TANK- at 300°F 46 p.s.i. Gage Press. L + V - 98.8 + 7.2					
	LIQUID WET GAS												VAPOR			LIQUID		
	Mol%	Mol%	MCF	Mol%	MCF	Gals.	Mol%	MCF	Gallons	Mol%	MCF	Gallons	Mol%	MCF	Gallons	Mol%	MCF	Gallons
Methane	36.4	30.3	402.6	47.3	394.8	-	8.0	135.8	0.00	44.8	756		4.9	39.0	661	0.1	0.8	98
Ethane	78.8	17.3	229.8	24.1	201.0		28.8	478.0	0.98	105.0	2,800		8.6	69.3	1,680	0.3	28.7	980
Propane	256.7	27.8	368.0	27.6	229.0	6,180	140.0	2,645.0	4.82	536.7	14,700		32.2	258.0	7,110	2.7	277.7	7,560
Iso-butane	280.4	8.8	117.8	0.7	6.0	196	111.8	2,645.0	2.34	271.9	12,180		17.1	137.5	4,490	2.3	234.4	7,680
Butane	471.8	12.7	168.0	0.4	3.8	110	184.8	6,175.0	5.70	636.7	20,000		25.5	208.0	6,390	4.1	432.7	13,610
C Residue	806.9	1.0	13.8	-	-	-	13.8	488.0	1.98	220.2	7,980		3.2	25.5	925	1.9	194.8	7,055
TOTALS	1,446.0	98.0	1,300.0	100.0	834.0	6,486	446.0	12,966.8	17.80	1,914.0	86,064		91.8	738.8	21,256	11.4	1,180.8	36,928
Abs. Oil	7,822.0	2.0	26.0				1,724.0	2,055.0	2.820	2,246.0	65,800		8.2	70.8		88.6	9,176.8	
Total	9,270.0	100.0	1,326.0				2,190.0	16,991.8	100.00	11,160.0	72,864		100.0	804.0		100.0	10,356.0	

Lean oil - 98.8 g.p.m. ? Theoretical Plates- Iso-butane Factor - 1.3
Total Lean Oil - 446.8 g.p.m. Rich Oil - 98.8 plus 9.7 - 98.8 g.p.m. Temp. Rise 13°F
Lean Oil Gas Ratio - 142 gals. / MCF Dry Gas.
With a 1.3 Propane Factor and 60°F Lean oil Temp- ? theoretical plates- 95% of propane is absorbed- Lean Oil required g.p.m. equals gals / MCF Dry Gas Ratio

Columns	6	8	32	33	34	35	36	52	53	60	61	62	63	64	65	66	67	68	69	70	71	72
												38 plus 52	38 plus 53								**	

Component Material	450# Condensate Flash at 180# and 90°F L + V - 98.8 + 16.8						Gasoline COMPOSITE		Composite Gasoline Still O.H.			STILL R.D. ACCUMULATOR FLASH 80 p.s.i.-80°F L+V- 64.8+33.2				DE-PROPANIZER FEED Tank Flash-180#-100°F L+V- 92+8				Calculated Depropanizer Tank Gas	
	450# Condensate		Vapor		Liquid		In Rich Oil					VAPOR		LIQUID		VAPOR		LIQUID			
	Mol %	MCF	Mol%	MCF	Mol %	MCF	Gals.	MCF	Gallons	Mol %	MCF	Gallons	Mol %	MCF	Mol %	MCF	Mol %	MCF	Mol %	MCF	Mol%	MCF
Methane	10.68	84.0	64.1	81.8	2.3	22.2	376	44.8	784.0	2.6	66.7	1,080	7.1	64.5	0.1	2.2	37.8	9.8	2.2	56.9	14.6	56.8
Ethane	8.01	63.0	19.8	21.3	6.8	41.7	994	105.0	2,800.0	5.7	146.7	2,494	13.1	119.0	1.7	27.7	17.0	6.4	6.8	142.3	33.4	130.3
Propane	18.46	121.8	15.5	17.7	15.6	104.1	2,880	536.7	14,700.0	24.8	640.8	17,500	39.8	362.0	16.8	278.8	28.1	6.5	24.0	634.3	51.7	201.4
Iso-butane	6.94	84.6	3.4	3.9	7.8	50.7	1,682	371.9	12,180.0	16.3	422.6	12,772	15.6	142.8	16.7	280.1	9.1	2.1	18.4	480.8	0.3	1.0
Butane	18.61	190.2	6.6	7.8	19.2	122.7	3,862	636.7	20,000.0	29.3	756.4	22,862	22.2	201.8	33.2	556.9	10.8	2.6	29.5	756.6		
C Residue	42.40	333.9	1.8	2.1	49.3	331.6	11,960	220.2	7,980.0	21.3	662.0	19,940	2.2	20.8	31.7	531.6	1.2	0.3	21.6	551.7		
TOTALS	100.00	787.5	100.0	114.3	100.0	672.5	21,704	1,914.0	58,064.0	100.0	2,697.2	79,788	100.0	910.0	100.0	1,677.2	100.0	28.9	100.0	2,661.2	100.0	389.5

Note: All computations are slide rule accuracy only.

* In column 44 used only 9 mcf. vapor pressure of total material is 157 psig. at 90° F.

** Compare assumed and calculated depropanizer vent gas. Propane balance is off about 28 mcf.—close enough for slide rule accuracy. Refer to columns 71-72 and 32-33. Raising depropanizer column pressure will reduce the propane content of the accumulator vent gas when making maximum yield of propane.

*** 910.0 mcf. to be compressed by the recompressor to 150-157-psig. pressure and re-contacted with the still accumulator excess liquid in the coolers in the cooling tower on the way to the de-propanizer feed tank.

Figure 6-A. Material Process Flow Calculations.

possible to design all the equipment in the absorption circuit. The selection of gas engine and steam-driven pump equipment was tied in with a utilization study of the exhaust steam usage possible; i.e., still agitation, de-propanizer and de-butanizer reboilers and for feed-water heat.

From a study of Figure 3 it is noted that excess exchange surface needs to be provided in order to provide rich oil temperature control to the re-absorber, and to provide as high a flash tank temperature as possible. The higher the flash tank temperature the lower will be the heat load required by the fired-type preheater permitting a greater load capacity variation for the entire system.

The flash tank was made large enough to provide surge capacity for the distillation system. The fired-type preheater feed pumps take suction on the rich oil flash tank and are controlled by the fractionating still level control. The rich oil from the base of the re-absorber is pumped through the heat exchangers to the rich oil flash tank and are controlled by the level control installed on the base of the re-absorber.

The 450-psi. absorber and the 35-psi. re-absorber have fixed rate controllers installed on the lean oil lines to them. The 150-psi. absorber has a lean oil gas ratio controller installed, since the gas volume fluctuates to this absorber depending upon the dry gas fuel demand.

The still vapors are connected into the re-absorber as well as to the re-cycle compressor, so that when the compressor shut down for any purpose these vapors are not lost and have an emergency place to go. For this reason it has been found desirable to operate the still pressure some 5 to 10 psi. higher than the re-absorber pressure.

Propane Refrigeration Unit

Selective absorption is further effected through the chilling of the wet gas and the lean absorption oil. Chilling the lean oil makes possible lower oil circulating rates for a given iso-butane absorption factor. Chilling of the dry gas delivered at 500 to 600 psi. pressure to the gas company's sales distribution system is necessary during the summer months in order to obtain a 60° F. temperature. The formation of hydrates prevents carrying the gas temperature much below 60° F. while the lean oil temperature may be carried down to 45-50° F. if so desired.

From the flow sheet for the refrigeration unit, Figure 9, it is seen that liquid propane from the de-propanizer column is used for filling the accumulator tank after it has been properly cooled. From the accumulator tank the liquid propane passes through a heat exchanger in which the cold propane gas from the chillers in turn cools the propane liquid before expansion. From this exchanger the propane liquid en-

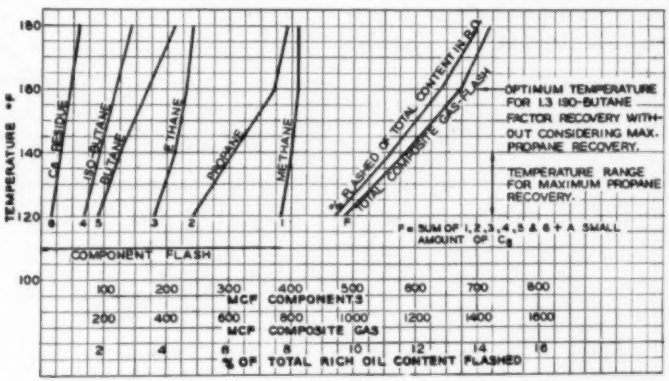

TEMPERATURE °F
180
160
140
120
100
C6 RESIDUE
ISO-BUTANE
BUTANE
ETHANE
PROPANE
METHANE
% FLASHED OF TOTAL CONTENT IN BOTTOM TOTAL COMPOSITE GAS FLASH
OPTIMUM TEMPERATURE FOR 1.3 ISO-BUTANE FACTOR RECOVERY WITHOUT CONSIDERING MAX. PROPANE RECOVERY.
TEMPERATURE RANGE FOR MAXIMUM PROPANE RECOVERY.
P = SUM OF 1, 2, 3, 4, 5 & 6 + A SMALL AMOUNT OF C6
COMPONENT FLASH
100 200 300 400 500 600 700 800
MCF COMPONENTS
200 400 600 800 1000 1200 1400 1600
MCF COMPOSITE GAS
2 4 6 8 10 12 14 16
% OF TOTAL RICH OIL CONTENT FLASHED

Figure 7. Curves Showing Relation Between Gas Flashed at 35-psig. Pressure in Base of Reabsorber, and Temperature of Flash.

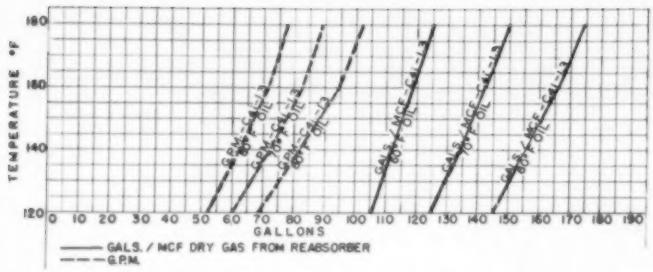


Figure 8. Curves Showing Relationship Between Total Reabsorber Oil Circulated and Oil Gas Ratio and Various Temperatures Based Upon a 1.3 Isobutane Absorption Factor.

Absorption Factor C_4i Based on 1.3, and C_1 C_2 C_3 Equilibrium at 90°, with the Absorbed Medium at Temperatures Indicated, and Based on Seven Theoretical Plates for 160° F.-180° F. **Note:** Gpm. Curves Based Upon Gas Throughput Figures Shown in Figure 8.

ters the oil chiller, wet gas chiller, and 600-psi. dry gas chiller in parallel, being controlled by liquid level regulating valves installed on each vessel named respectively. In these chiller vessels the propane liquid is evaporated and passes off as a gas through back pressure regulating valves to a common gas line. The back pressure regulating valves are set to control or maintain at from 50 to 70 psi. depending upon the temperature desired. The propane gas after leaving the chillers passes through the heat exchanger to a compressor intake scrubber and to the compressor suction. The discharge gas from the compressor passes to atmospheric coolers in the induced draft cooling tower where the propane gas is condensed as a liquid at approximately 150 psi., totally condensing. The propane liquid then flows back to the accumulator tank.

Any lubricating oil usually accumulated in the bottom of the chillers is bled off to the intake scrubber and then bled to the drain system.

The volume of propane gas handled by the compressor will vary to meet the temperature conditions required. A bypass between the suction and discharge at the compressor station is installed for the operator to open when low gas rates and cold atmospheric temperatures are encountered. This is necessary in order to prevent propane liquid forming on the compressor cylinder walls. If desired this by-pass valve could be replaced with a regulator operated by the suction pressure.

Gas Flow Through the Plant

The 50 psi. wet gas flow from the Helm field together with the wet gas from the Lanare field is piped through a wet gas intake scrubber and composite gas intake meter to the 50-psi. compressor suction header. The 50-psi. pressure wet gas is compressed to 150 psi. and is piped to atmospheric coolers in the induced-draft cooling tower and then joins with the 150-psi. wet gas from the Riverdale field on the way to the 150-psi. wet gas scrubber. The wet gas is then piped to the compressor suction header and to the 150-psi. absorber through a regulating valve controlled by the field fuel gas line pressure. Vent gas from the de-propanizer reflux accumulator and from the de-propanizer feed tank is also connected into the wet gas line to the 150-psi. absorber. The vent gas from the de-propanizer reflux accumulator is alternately tied to the field fuel in case a maximum yield of propane is not desired.

The 150-psi. wet gas is compressed to 450 psi. and is connected to atmospheric coolers in the cooling tower and then to the wet gas chiller where it is further cooled to 60° F. temperature. Leaving the chiller the 450-psi. wet gas joins additional wet gas from the Helm field after the meter manifold. Connections have been left so that the field 450-psi. wet gas may also be chilled at a later date if desired. The composite 450-psi. wet gas is piped to a scrubber for the removal of condensate, and is then piped to the 450-psi. absorber.

The dry gas from the 450-psi. absorber is piped through a dry-gas scrubber, meter, back-pressure regulating valve where it then splits. One part is taken through another back pressure regulating valve and delivered to the gas company's glycol dehydration unit, and the other part is piped to the 450-psi. dry gas compressor suction header. The 450-psi. pressure dry gas is compressed to 500-600 psi. as desired and is piped to atmospheric coolers in the induced-draft cooling tower, to dry-gas chiller, and to a scrubber. From the dry-gas scrubber the gas passes to a sales meter and to the other gas company's pipe line distribution system.

Fuel for the boilers and fired-type preheater is taken from the 35-psi. absorber primarily with a make-up connection from the compressor fuel piping. The dry gas at 140-150 psi. passes from the absorber through a meter and back pressure regulating valve to field fuel. The compressor fuel connection is taken off ahead of the meter. The compressor fuel passes through a

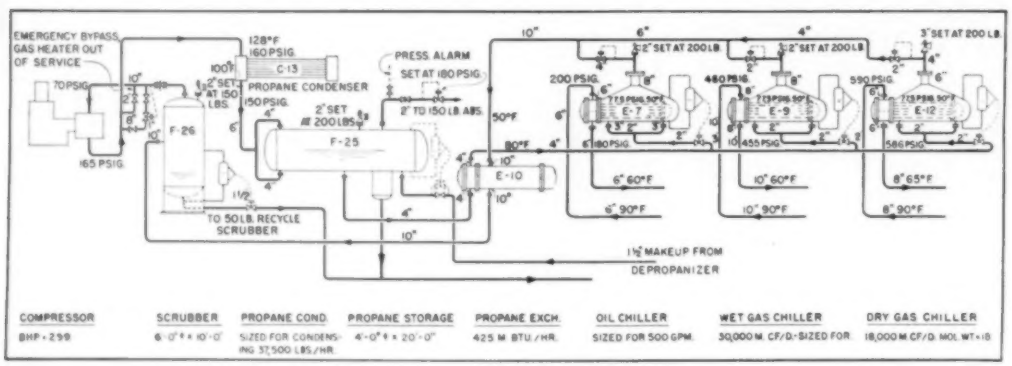


Figure 9. Propane Cooling Flow Sheet.

reducing regulator to a scrubber. It is reduced to around 30 psi. pressure. Into the fuel gas line to the scrubber there is connected an emergency 50-psi. wet gas connection for make-up purposes in case the fuel pressure should drop too low and for emergency shut-down purposes. The compressor fuel pressure is further reduced in pressure for the four-cycle gas-engine driven auxiliary pumping equipment, and is further reduced at each gas engine driven compressor to around 15-psi. by the compressor fuel regulating valve.

All of the main gas services pass through a meter manifold. Each gas service is protected with a stack to air line in which is installed a back pressure regulating valve. On each service stack to air line is installed a meter for measuring any gas that might pass to air due to irregular plant operation. Each service stack to air line is connected into one common large stack line which is located in the southwest corner of the plant at a safe distance away from all equipment. For the purpose of piping convenience the arrangement at the meter manifold has been worked out into parallel meter runs.

Drip Condensate

In general the drip condensate from the 450-psi. gas gathering system is expanded into the 50-psi. gathering system in the field. At the plant, the 450, the 150, and the 50-psi. condendensate from the vertical drip pots located at the entrance of the wet gas to the plant are all connected into the 50-psi. wet gas intake scrubber. The drip condensate from the 50-psi. wet intake gas scrubber and from the 35-psi. dry gas scrubber are piped to a 6-foot-diameter by 20-foot-long dirty storage tank. The oil drains from the 450-psi. dry gas scrubber and drip pot are also connected to the 35-psi. dry gas scrubber.

The condensate from the 450-psi. wet gas scrubber, after compression and cooling, is piped to the 150-psi. pressure wet gas scrubber where it is flashed. The condensate from the 150-psi. scrubber is further flashed into the 35-psi. recycle scrubber. From the 35-psi. recycle scrubber the clean condensate is taken into a 6-foot-diameter by 20-foot clean condensate storage tank. In case the 150-psi. condensate turns up dirty in color, it can be alternately flashed into the 50-psi. wet gas scrubber where it then goes to the dirty drip tank. The clean and dirty drip tanks are good for 30-psi. pressure. Vent vapor from these two storage tanks is connected to the stack to air line and to the boiler plant fuel line. Pressure is maintained by means of a back pressure regulating valve.

The clean drops are pumped from the clean drip condensate storage tank by means of a 6 x 4 x 6 horizontal duplex steam pump into the reflux line to the fractionating still.

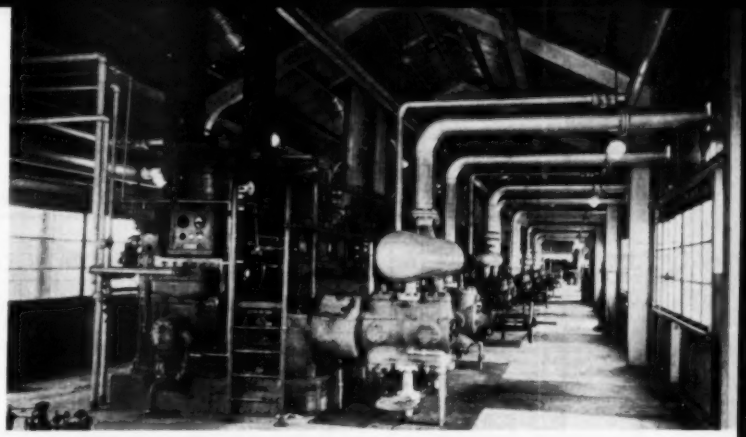


Figure 10. Interior of Compressor Building.

The dirty drips are pumped from the dirty drip storage tank by means of a 6 x 4 x 6 horizontal duplex steam pump to the oil conditioning unit heater.

Oil Conditioning Unit

The oil conditioning unit has to serve two purposes, namely to clean up dirty absorption oil and to recover absorption oil and gasoline from the dirty drip condensate. The unit consists of a vertical-tubed fire-type heater. The vapors out of the heater are connected to a tubular condenser mounted on the top of an accumulator. The dirty absorption oil is taken from the base of the fractionating still to the heater. The oil-conditioning heater has an evaporating capacity around 5 gpm. at 450° F. The overhead vapor line from the heater is laid to grade to the condenser which in turn is liquid sealed by the accumulator tank which is placed immediately underneath the condenser. This causes a vacuum to be created on the heater by the condenser. A vacuum of 10 inches of mercury is

Location		General Service										Alternate Service							
Unit No.	Marine H.P.	Compressor Gas Service	Cylinder Size	Gas Symbol	M²CF	Suct. Pressure	Disch. Pressure	Suct. Temp. °F	Clearance %	V.E. %	Compr. B.H.P.	Gas Symbol	M²CF	Suct. Pressure	Disch. Pressure	Suct. Temp. °F	Clearance %	V.E. %	Compr. B.H.P.
						p.s.i.	p.s.i.							p.s.i.	p.s.i.				
K-1	400	Recycle Gas Propane	12"x14" 12"x14"	D	1.35	38	160	90°	22.6	55.5	100								
		Propane Gas	(2)12"x14" (2)12"x14"	E	6.50	70	165	80°	28.0	72.5	300	E E	1.47 6.62	55 55	165 165	80° 80°	9.32 11.9	80.0 76.2	50 317
K-2	400	50# Wet Gas Recycle Gas	12"x14" 12"x14"	A	2.62	45	155	90°	12.6	79.5	162	D	1.35	35	160	90°	17.2	61.5	100
		150# Wet Gas	(2)7"x14"	B	3.56	150	460	90°	24.3	62.3	230	B	4.74	150	460	90°	7.16		306
K-3	500	50# Wet Gas 150# Wet Gas	12"x14" (2)7-3/4"x14"	A B	2.66 5.10	45 150	155 460	90° 90°	9.3 17.5	84.0 72.3	171 326	None None							
K-4	500	50# Wet Gas 150# Wet Gas	9½"x14" 9½"x14"	A	1.50	45	155	90°	11.3	81.0	97								
		150# Wet Gas 430# Dry Gas	7 3/4"x14" 7 3/4"x14"	B	3.00	150	460	90°	8.4	85.0	194	B	1.74	150	460	90°	20.4	68.0	112
		150# Wet Gas 430# Dry Gas	7 3/4"x14" 7 3/4"x14"	B	3.00	150	460	90°	8.4	85.0	194	C	9.0	430	600	90°	8.4	94.5	199
K-5	500	50# Wet Gas 150# Wet Gas	9½"x14" 9½"x14"	A	1.50	45	155	90°	11.3	81.0	97								
		430# Dry Gas 150# Wet Gas	(2)7-3/4"x14" (2)7-3/4"x14"	C	18.00	430	600	90°	8.4	94.5	398	B	1.74	150	460	90°	20.4	68.0	112
												B	6.00	150	460	90°	8.4	85.0	386

Figure 11. Gas and Compressor Detail Data.

Note: Balanced total compressor horsepower for each unit equals the rated engine h.p. for each service and for maximum gas loading for each compressor cylinder. At a later date Unit No. K-1 was connected to the 50-pound wet gas service for use during the winter months until another compressor unit could be installed. Due to the excellent performance of the induced draft cooling tower it was found possible to shut the propane refrigeration unit down during the winter months. This also provides another emergency spare set up in case another compressor goes down.

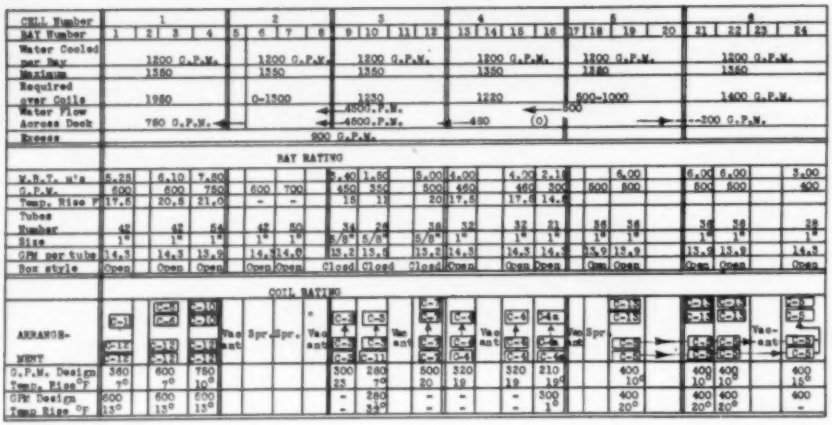


Figure 12. Induced-Draft Cooling Tower Arrangement and Heat Data.

the optimum pressure for this type of unit.

When the dirty drip condensate is reclaimed it is pumped from the dirty drip tank to the heater. The liquid is pumped from the accumulator to the storage tanks, or to the fractionating still, or to the rich oil into the re-absorber. The oil conditioning unit is operated alternately for reclaiming dirty drips and for reclaiming dirty absorption oil. The accumulated heavy gravity black oil that accumulates in the base of the heater has to be drawn at quite frequent intervals in order to prevent coking up the heater. When to draw this oil can be determined by gravity or by the fact that as the material gets heavier the temperature has to be increased in order to maintain a proper leave and a maximum temperature can be set for withdrawal of this oil when it has been reached.

It is expected that when the volume of dirty drips exceeds the capacity of the unit that it will be necessary to install a reclaiming still. This type of reclaiming or oil conditioning unit was installed at the recommendation of the operating department. It does not have the facilities however for making controlled molecular weight oil. It merely cleans the absorption oil and removes the real heavy fractions.

Coil Designation for Above Figure

C-1—150-pound Wet Gas-A
C-2—450-pound Wet Gas-B
C-3—600-pound Dry Gas-C
C-4—Lean Oil Coolers
C-5—Gasoline Condensers
C-6—Recycle Gas-D
C-7—De-propanizer Condensers
C-8—Propane Cooler
C-10—De-butanizer Condenser
C-11—Stabilized Gasoline Cooler
C-12—Jacket Water Coolers-Engine Jacket
C-13—Propane Condensers, Refrigeration Cycle

Compressor Station

The compressor station consists of two two-cycle 400-hp. gas engine compressor units which were moved from another corporation gasoline plant; three two-cycle 500-hp. gas engine compressor units; two gas engine driven and one steam turbine driven engine circulating water pumps; starting air compressor and instrument air compressor both gas engine driven; and two additional bays of building for parts storage and for overhaul and for maintenance work.

In deciding the layout for the compressor station certain quantities of gas were selected from the field data, together with the gas analysis and the process calculations the plant layout was selected. From this data the compression ranges and capacities selected are observed to be namely, 3600 mcf of 45-psi. wet gas to be compressed to 155 psi., designated as gas A; 14,100 mcf per day of 150-psi. get gas to be compressed to 460 psi., designated as Gas B; 14,000 mcf per day of 450-psi. dry gas to be compressed to 600-psi. pressure designated as gas C; 1500 mcf per day of 35-psi. still vapors to be compressed to 160-psi. designated as gas D; and 7325 mcf per day of propane gas for refrigeration from 70 to 165-psi. or from 55 to 165 psi. range designated as gas E. The total horsepower for compression represented by these figures is approximately 1800 to 1870. About the time the layout was decided it was further requested to increase the 50-psi. wet gas quantity to 6000 mcf per day and to provide 100 percent spared capacity for the 450 to 600 psi. compression service or gas C.

In laying out the compressor station provisions were made so that in case of an engine shut down, the load could be shifted to completely load the remaining units in operation, and in case there was an excess quantity of wet gas it could be processed through the 150-psi. absorber and allowed to go to air if necessary. Final arrangement of the compressor unit sizes was selected on this basis, remembering that there are operating two-cycle gas engines which should be operated under a full load condition in order to obtain the best efficiency. Equipment on hand also had to be fitted into the arrangement. Clearance pockets, valve lifters, and valve in head unloaders were selected so that the compressor cylinders could be operated under two

Gas Designation	N Factor at Suc. Temp.	Molecular Weight	H.P. per MCF	Unit Designation	Shut Down	Max. A Gas	CAPACITY MCF RANGE				D Gas	E Gas
							Capacity Variation	Max. B Gas	Capacity Variation	Max. C Gas		
				#1 Unit	No spare capacity for Gas E						1.35	6.50-7.00
A	1.23	21.0	64.3	#2 Unit	Spares Unit #1 on Gas D						0	
B	1.19	23.0	64.5	All	0	8.18	<——>	14.66	<——	18.00		
C	1.26	17.5	22.1	4 Units	K-1	5.66	<——>	14.66	<——	18.00		
D	1.13	49.0	74.0	4 Units	K-2	5.66	<——>	11.10	<——	18.00		
E	1.13	43.8	56.4	4 Units	K-3	5.52	<——>	9.56	<——	18.00		
E	1.13	43.8	46.1	4 Units	K-4	6.68	<——>	8.66	<——	18.00		
				4 Units	K-5	6.68	<——>	8.66	<——	18.00		
				4 Units	K-5	6.68	<——>	10.16	<——>	13.50		
				4 Units	K-5	6.68	<——>	11.66	<——>	9.00		
				4 Units	K-4	6.68	<——>	10.16	<——>	13.50		
				4 Units	K-4	5.18	<——>	10.40	<——	18.00		
				4 Units	K-4	5.18	<——>	11.90	<——>	13.50		

Figure 13. Gas and Compressor Summary Data.

Note: Maximum capacity ratings are shown in the table and the direction of the arrow indicates that when one gas quantity is reduced the other gas quantity can be increased in the direction of the arrow by rearranging the clearance on the compressor cylinders. The entire range of capacity has not been indicated but only the range at the high capacity limits. By combining the H.P. per MCF with the measured gas compressed, a fair estimate of horsepower balance can be made.

alternate pressure conditions and under two alternate gas services in some cases. Figure 11 shows the final arrangement selected. There are three compressor cylinders mounted on each gas engine unit. From this data a summary, Figure 13, was compiled.

The compressor engine jacket water circuit is a closed system. The engine jacket water is circulated by means of two direct connected gas engine driven centrifugal water pumps and a spare steam turbine driven standby. The pumps take suction on the surge tank and pump the water through the engine jackets. From the engine jackets part of the water passes through the compressor cylinder jackets and back to the surge tank, the other part of the water is piped to atmospheric cooling coils in the induced draft cooling tower and then to the surge tank. There is also installed a bypass line from the water line to the cooling coils back into the surge tank. This bypass together with the water from the compressor jackets is used to control the temperature of the engine jacket water at around 120° F. Since the atmospheric cooling sections are designed with low pressure drop only approximately five pounds extra pressure are added to the engine jacket pressures. The hot engine jacket water to the compressor jackets results in longer ring life and less compressor cylinder wear, operating on wet gas. The engine lubricating oil coolers are cooled by a separate water circuit taken from the discharge of the induced draft cooling tower circulating water pumps and returned to the cooling tower basin.

Induced-Draft Cooling Tower

Preliminary weather investigation revealed periods as high as 30 days with very little wind available and at the same time wet bulb temperatures as high as 72° F. Also there was found that ground fogs due to irrigation at certain times of the year, caused high wet bulb temperatures and high humidity conditions. This data led to the consideration of the installation of an induced draft cooling tower.

A 24-bay, 6-cell 24 feet wide by 144 feet long by 40 feet high cooling tower was installed. On the top of each cell of 4-6 foot bays was installed a 12-foot (diameter) induced-draft fan assembly driven by a gas engine. Atmospheric cooling sections 20 feet long were arranged so that they could be stacked four high in the base of the cooling tower. The guaranteed rating of the cooling tower is 7200 gpm. of water from 100° to 80° F. with a 72° F. wet bulb temperature. This represented 0.4 inch of water draft in the entrance of the fan duct which equals a fan velocity of approximately 302 feet per minte.

Design features in this tower include

a) vapor stack with damper, installed vertically from the atmospheric cooling section through the drift eliminators to permit the removal of hot water vapor;

b) pick-up and re-distribution system with water control levers carried down so as to be operable from the ground;

c) Special hot water control arrangement on certain cooling sections; i.e., cooling gas that has to be maintained above 60° F. to prevent the formation of hydrates;

d) Alternate spacing of coils with passageway between to permit easy access for cleaning;

e) Stacking of atmospheric cooling sections with cold services above hot services so as to economically permit the flow of sufficient water over the coils in order to reduce scaling tendencies.

Figure 12 shows an approximate distribution layout for the water and for the heat loads in the induced draft cooling tower.

Fractionating Unit

In general the fractionating unit was designed to produce stabilized 18

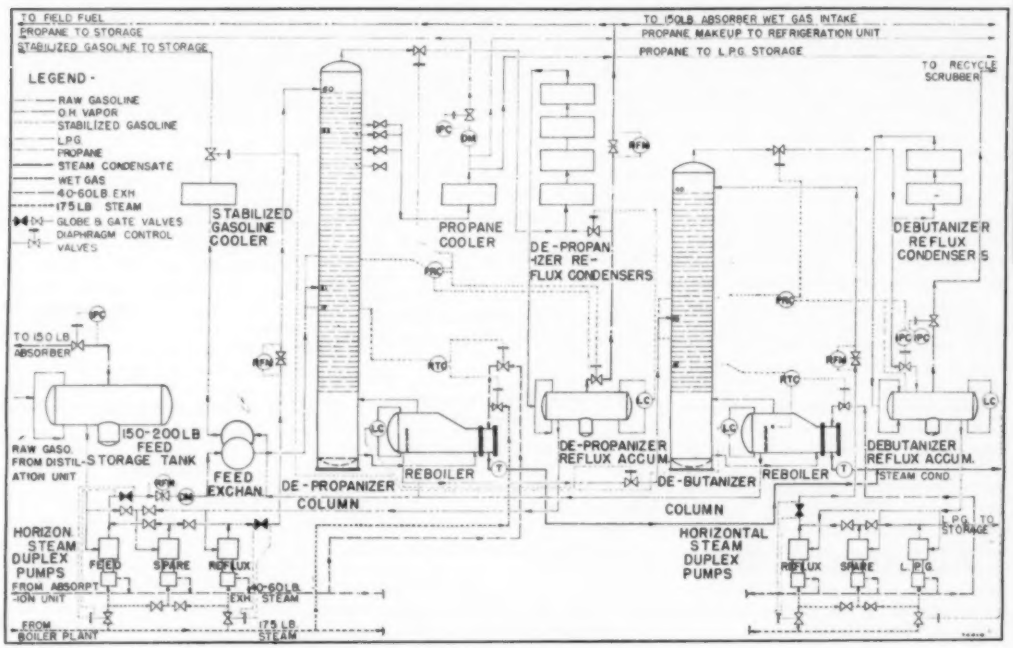


Figure 14. Fractionating Unit Flow Sheet, General Petroleum Corporation's Burrel Plant.

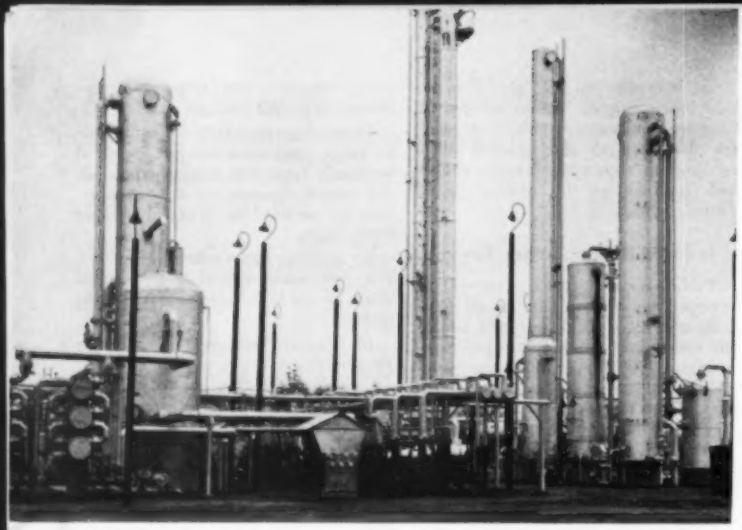


Figure 15. Process Equipment with Heat Exchangers, Distillation Columns, Pumps, Fractionating Columns and Absorbers, from left to right.

to 26-pound Reid vapor pressure gasoline, liquid propane, and a mixture of butanes for further mixture with propane, to make an LPG. sales product. A simplified flow sheet, Figure 14, shows the conventional flow in which the raw gasoline is de-propanized in the first column with the bottoms from this column feeding the de-butanizer column. In the debutanized column the stabilized gasoline is drawn from the bottom of the column and LPG. product is taken overhead. The vent gas from the de-propanizer reflux accumulator may be taken to field fuel or to the 150-psi. absorber as desired. Any vapor from the de-butanizer reflux accumulator is taken to the recycle scrubber and reprocessed.

The bottom temperatures of these columns are controlled by the temperature of some plate in the column below the feet plate, or several plates up from the bottom of the column as determined experimentally in the field.

The de-propanizer column has ten more fractionating plates installed than are normally required for this type of column. The purpose of these plates is to permit the withdrawal of propane having approximately 99 percent purity at from 6 to 10 plates below the top plate. By using a large reflux accumulator and over refluxing the column maximum withdrawal of the propane content can be accomplished. Connections have also been installed so that a stripper operation could be installed at some later date for a continuous removal of the maximum percent of the propane content having a 93-99 percent purity.

The fractionating plates installed in this de-propanizer column are specially designed by the writer and the C. F. Braun Company engineers. A balanced vapor and liquid design has been used which permits a higher maximum capacity than usually found in 48-inch (diameter) columns. This design permits a considerably larger number of bubble caps to be installed than are usually found in conventional designs.

The stabilized gasoline from the debutanizer column is piped from the column through a re-boiler, feed heat exchanger, atmospheric cooler in the induced draft cooling tower, and to the storage tanks. The heat exchanger delivers heat to the raw feed gasoline on its way to the de-propanizer column.

Horizontal duplex steam pumps used for feed and for reflux, are rate controlled. A throttle valve placed in the discharge line from the pump provides the necessary pressure drop, which varies with the rate, for controlling the steam to the duplex pumps. This practice is found to avoid pulsation troubles that are found to give trouble with the conventional rate control method.

Exhaust Steam and Steam Condensate

Exhaust steam from the horizontal duplex steam pumps was balanced against the heat requirements for the de-propanizer reboiler, de-butanizer reboiler, feed water heater, and for still agitation purposes. It was found to be desirable, for control purposes, to provide a lesser amount of exhaust steam than that actually required so that a small quantity of live steam would be needed to balance the requirements. This reduces the exhaust steam going to the air to a minimum when considering pumps that are operated intermittently, such as shipping pumps. In order to accomplish this balance the remainder of the pumping load was gas engine driven. The de-propanizer reboiler had to be designed with ample surface in order to obtain the maximum temperature with the lowest exhaust steam pressure without undue cost.

All horizontal duplex steam pumps in the distillation unit area and in the storage tank and shipping area are connected to a common exhaust steam header which is operated at from 40 to 60 psig. The excess exhaust steam from this header flows through a back-pressure regulating valve installed in a line to the feedwater heater which is located at the boiler plant. The line to the feedwater heater is operated at from 2 to 5 psig. which is controlled by a back-pressure regulating valve installed in a stack to air line. The exhaust steam from the shipping pump areas can also be tied alternately into the 2 to 5-psi. line to the feedwater heater as desired. A reducing regulator controls the amount of live steam make-up to the 40-60 psi. exhaust steam header. The 40-60 psi. line is connected into the still through a rate control and into the de-propanizer and de-butanizer reboilers through temperature controlled steam regulating valves. The horizontal duplex boiler feed pump exhaust steam is connected into the 2 to 5-psi. exhaust steam header to the feedwater heater.

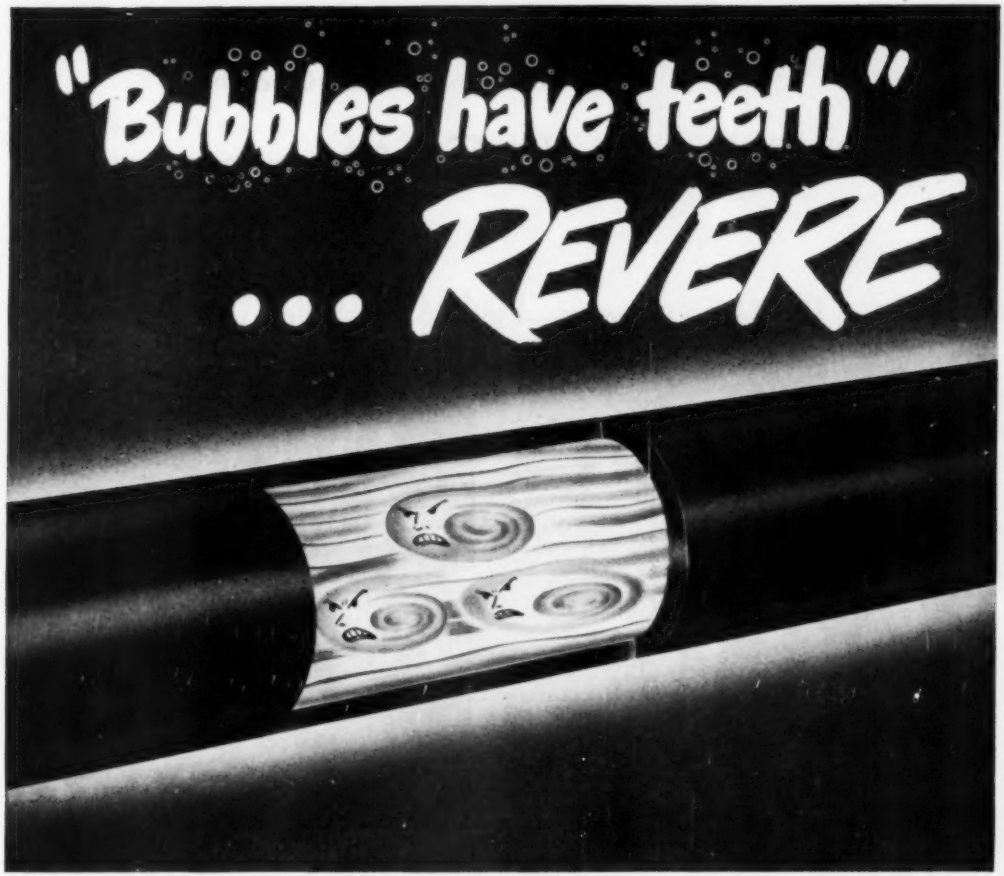
Steam condensate is piped from the reboilers, and from steam traps to a hot condensate flash or surge tank which is located at the classifying sump. Any accumulated lubricating oil is skimmed off from the surge tank into the classifying sump. The hot water condensate is pumped to the boiler feed tank.

Cold condensate water from the gasoline de-watering pots and the run-down accumulator installed at the still is taken to a separate compartment in the classifying sump where any contained gasoline may be removed. From this compartment in the classifying sump the cold condensate is pumped to the boiler feed tank.

Contractors

Bechtel McCone Corporation made the necessary drawings and constructed the gasoline plant under the direction of the engineers for General Petroleum Corporation.

Similarly Pacific Pipe Line Construction Company installed the field gathering systems, including the gas booster compressor stations.



SOME years ago Revere said that "Bubbles have teeth." It is still true. Air bubbles in a condenser can eat away at the tubes quite rapidly, and become a cause of failure with consequent re-tubing. Air-entrainment, as it is called, acts in several ways, all destructive to tubes. Air contains oxygen, which directly attacks most metals, forming oxides. Carbon dioxide in solution dissolves these oxides. That is not all. Air bubbles add to the erosion effect of turbulent flow. The higher the velocity, the worse the effect, and the more swift and serious is the combination of erosion and corrosion at points of greatest disturbance. Every effort should be made therefore to keep air from being carried into the cooling water. If you are troubled by frequent re-tubing of your condenser, get in touch with Revere, but first save a few samples from failed tubes for examination by our laboratories to determine the cause of failure. Many users of condenser tubes have found our collaboration exceedingly valuable, and we are always glad to cooperate in an effort to extend tube life.

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Maintenance and Operation—

HOW TO DO IT

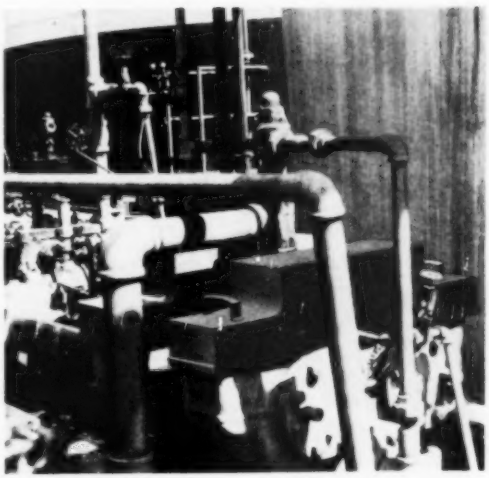
HOW TO—Test Heavy Relief Valves In Place

REMOVING and transporting fractionator relief valves that weigh 1200 pounds to the plant machine shop for testing and checking can hardly be considered a simple, easy task. To eliminate such a procedure, two members of the maintenance department, Mechanic Ray Hickman (left) and Luke Sullivan, maintenance helper, at the Heath refinery of The Pure Oil Company, worked out a simpler, easier, and safer method of testing the "big boys" in place on the column.

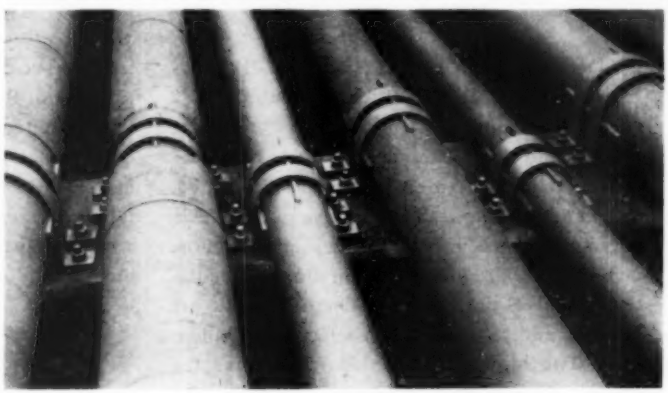
In the photograph, Hickman is shown holding a blind plate provided with an air connection and a pressure gauge. The blind plate is inserted between the connecting flanges of the valve, and air pressure is applied to check the set pressure of the relief valve.

HOW TO—Use Lead Shields Over Valve Plugs

WHEN handling doctor solutions or corrosive acids for treating such petroleum products as gasoline and kerosine with reciprocating pumps, leaks occurring around the valve plugs may cause the material to be splashed upon the operators inflicting acid burns, or on the surrounding equipment and painted surfaces.



Prevention of such damage can be accomplished by the use of a heavy sheet lead cover over that part of the pump around the pot valve covers. The seams of the lead sheets used to make the cover are burned to seal them and strengthen the cover. The weight of the lead sheets keeps the cover solidly in place. Handles are attached for removing the cover when it is necessary for the operator to get to the valves.



HOW TO—Hold-Down Piping

HOLD-DOWNS that permit lengthwise movement and maintain relative spacing of process piping are illustrated above. Concrete piers are poured with the top surface a couple of inches above grade. Hold-down bolts are set in the piers before pouring concrete. Flat bars of steel laid on the piers support the piping and provide slip-ways for the pipe to move upon during contraction and expansion. As guides for the pipe and to afford minimum contact area between the pipe and the slipways, quarter inch square strips of iron are welded at 90 degree spacing around the pipe. Flat steel bars are formed into U-clamps to hold the piping in alignment and to help suppress any tendencies toward vibration.

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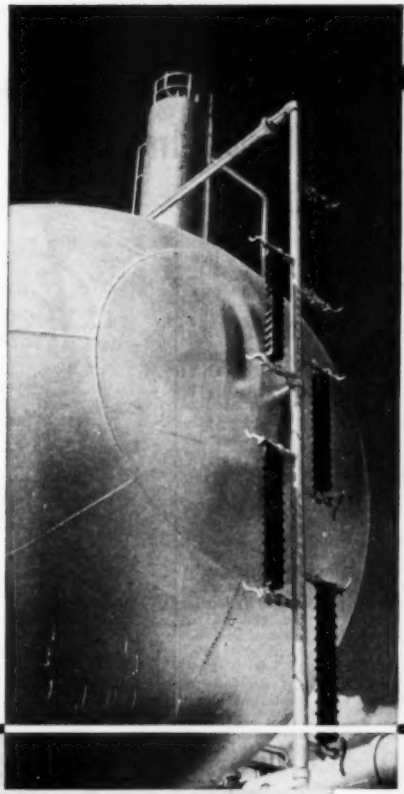

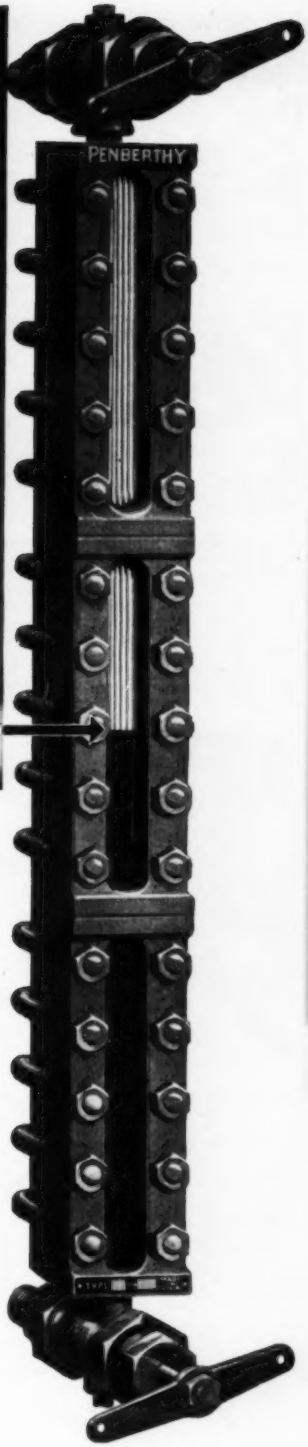

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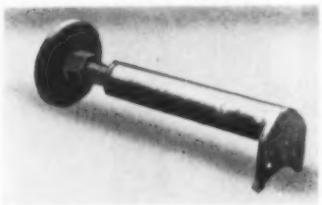
THE HOW OF—

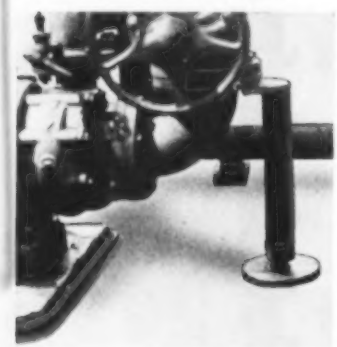
Piping Supports

PIPING connected to the flanges of pumps and like equipment often must be fully supported during repair or replacement operations. If the piping is adequately supported flange bolts are more readily removed and replaced, since the flanges remain in alignment. Also, damage to piping by overstress through lack of support can be avoided.

The usual procedure involves the use of wooden blocks to support the disconnected piping. This method requires a large number of blocks so that the workmen can select the sizes needed. Occasionally, block and tackle equipment is used when space and other conditions permit. Both methods require time and manpower, and if not carried out correctly, are hazardous.



A simple jack-type support has been devised for this purpose. As will be noted from the photograph, the support consists of a heavy steel stem threaded and equipped with a large nut. The height of the stand can be adjusted by screwing the nut up or down on the stem of the stand to increase or decrease the height as needed.



Pipe line supports to remove weight of vertical sections from pump castings.

The lower end of the threaded stem is welded to a heavy steel base plate. On the top end of the body, the stand is equipped with an offset lip. The edge of the lip is curved to fit the contour of the fitting at the companion flange. Also, the lip has two holes bored on centers that match those of two bolt holes in the flanges, so that the stand can be bolted to the flange.

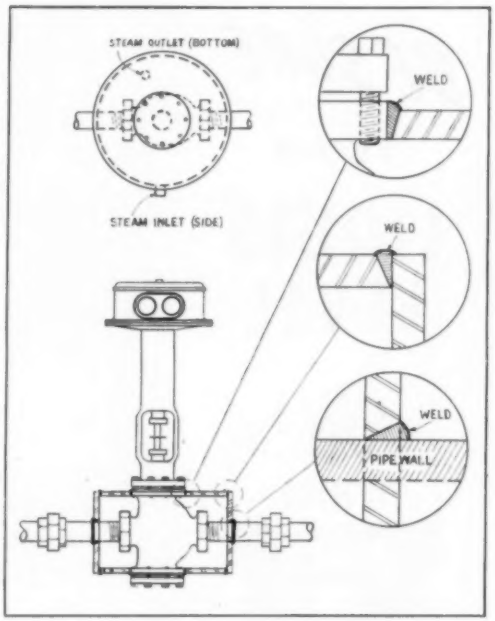
The stands are simple in construction and inexpensive and can be made in the plant's shop.

HOW TO—

Build Welded Steam Jacket to Prevent Gas Regulator From Freezing

WHERE regulators are handling gases containing hydrates, it is often necessary to provide some means to prevent the expansion-refrigeration effect of the gases from "freezing up" the the regulator valves. One plant's maintenance crew have devised a steam jacket for control valves used in such services.

The jacket is fabricated from pipe and plate as shown in the sketches and photograph. Regulator inlet and outlet connections are made up through holes in the jacket and the line connections to the regulator can be seal-welded if desired. Then the jacket is welded to the connecting lines. Half couplings are welded to the jacket to provide steam inlet and outlet connections. The steam passes around the valve body in flowing through the jacket. A steam trap should be used on the outlet side of the jacket and heat insulation provided for maximum steam economy.

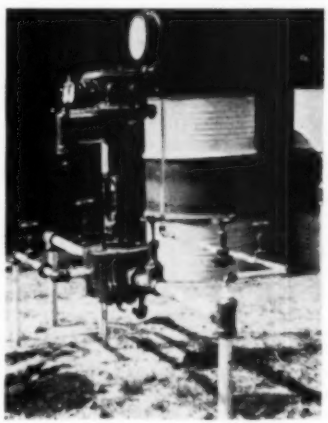


The enlarged sketches above show the method of welding the steam jacket to the valve body and connecting piping. The steam inlet is on the side of the jacket—the outlet on the bottom.

If a steam trap is used, or if the jacket is to be held above atmospheric pressure for any other reason, the jacket should be designed and also hydraulically tested in accordance with the usual procedures followed for pressure equipment. If steam economy is not a factor, and the jacket is to be operated at atmospheric pressure, the steam outlet connection should be left open and without threads to avoid any possible later application of pressure to an untested jacket. Note also that a leak between valve body and connecting lines can place full line pressure within the jacket. Seal welding and testing will lessen this possibility.

The sketches accompanying the photograph show the locations and types of welds on the forged-steel valve. Top right sketch shows the weld used for the top and bottom flanges of the valve. In the center sketch is shown the method of welding the end-plates of the steam jacket, and the bottom sketch shows welding of the line pipe to the steam jacket. The location of the half-couplings welded to the jacket for steam connections is shown in the top view of the valve.

Below: Steam-jacketed valve in service in gas line.



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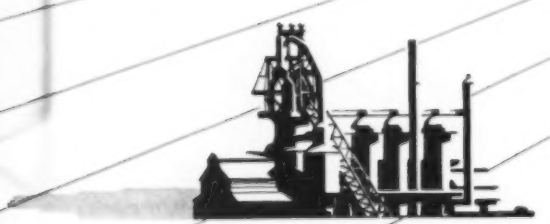
The cooperative experience and close relationship of the two divisions has proved advantageous to McKee clients in both industries.



ARTHUR G. McKEE & COMPANY

DESIGN, ENGINEERING AND CONSTRUCTION FOR THE PETROLEUM REFINING AND IRON AND STEEL INDUSTRIES

ENGINEERS AND CONTRACTORS • ESTABLISHED 1905
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THE MONTH in the INDUSTRY

* * *

Gulf Appointments

Gulf Oil Corporation has appointed H. P. Arbuckle as general auditor in charge of accounting and auditing for both domestic and foreign refineries and H. D. Taylor as assistant general auditor.

Retirement of Jesse K. Crownover, assistant secretary of the corporation and personal secretary of the president after 41 years service, also was announced.

T. E. Sunderland Elected

Thomas E. Sunderland, general counsel of Standard Oil Company (Indiana), has been elected a director of the company, succeeding Buell F. Jones. He is also a director of Pan American Petroleum and Transport Company, a subsidiary of Standard (Indiana).

API Division of Refining Mid-Year Meeting Set for Houston April 4-7

The annual mid-year meeting of the Division of Refining of the American Petroleum Institute will be held in Houston, April 4-7, in the recently completed Shamrock Hotel. Seven technical group sessions and an open dinner session are scheduled, Kenneth G. MacKenzie, chief technologist of The Texas Company, program committee chairman, said.

A highlight of the four-day meeting will be a continuation of the symposium on rapid methods of analysis. This symposium was held originally at the 28th annual meeting in Chicago in November, 1948, but because of the widespread interest, two additional symposium sessions have been arranged. Training, corrosion, vapor lock, management of refinery maintenance and waste disposal are other subjects to be covered at the meeting.

The preliminary program as announced by API follows:

Monday, April 4—**Symposium on Rapid Methods of Analysis II.** This is a continuation of the symposium session on this subject held during the annual meeting.

Tuesday, April 5—**Symposium on Rapid Methods of Analysis II.** Continuation of the Monday, April 4, session.

Tuesday, April 5—**Training.** Sponsored by the Committee on Training in Refining. Three papers: One will outline how the University of Texas survey has been found useful; one will be on the job training program of one of the oil companies, and a third will be on the outstanding training program of a small oil company.

Wednesday, April 6—**Corrosion.** Sponsored by the committee on corrosion. Papers include "Hydrogen Blistering," M. E. Holmberg, Phillips Petroleum Company, Bartlesville, Okla.; "Effect of Hydrogen at Elevated Temperatures," G. W. Nelson, Shell Development Company, Emeryville, Calif.; "Corrosion of Expansion Joints," H. F. Brown and W. M. Goryl, Standard Oil Development Company, Elizabeth, N. J., and "Cathodic Protection of Refinery Equipment," Derk Hoysteyn, Shell Oil Company, Deer Park, Texas.

Wednesday, April 6—**Vapor Lock.** Sponsored by the Automotive Research Committee. Three outstanding engineers from the automotive industry will tell the refining industry of the problems encountered in designing automotive engines to handle high vapor-pressure fuels.

Wednesday, April 6—**Open Dinner Session.** An outstanding speaker "on a subject of general interest to all refiners." Certificates of Appreciation will be presented to Thomas G. Delbridge, K. G. MacKenzie, and Walter Samans.

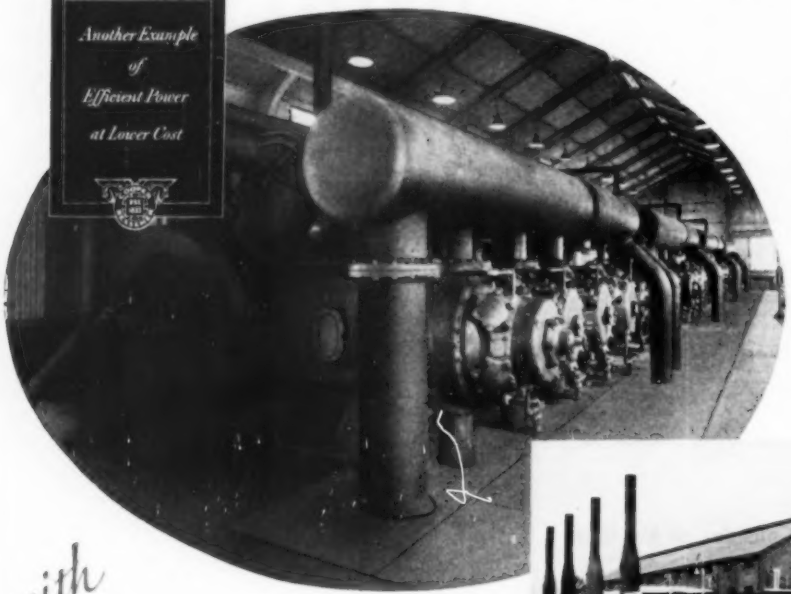
Thursday, April 7—**Management of Refinery Maintenance.** E. B. McConnell, The Standard Oil Company (Ohio), Cleveland, will preside. Papers to be presented include, "Cost of Control Maintenance," by R. S. Stewart, The Standard Oil Company (Ohio), Cleveland, Ohio; "Decreased Maintenance Costs by Better Scheduling," by G. R. Bryant, The Texas Company, New York; "Preventative Maintenance,"

Calendar of Meetings

MAR. 14-17	Chicago Technical Societies Council, Annual Chicago Production Show, Chicago, Hotel Stevens.
16	Commercial Chemical Development Association, Annual Open Meeting, New York, Roosevelt Hotel.
20-26	Second International Technical Congress, Cairo, Egypt.
24-25	New England Gas Association, Boston, Statler Hotel.
27 to April 1	American Chemical Society, Division of Petroleum Chemistry, Spring Meeting, San Francisco.
28-30	Western Petroleum Refiners Association, San Antonio, Plaza Hotel.
29 to April 1	Nineteenth Annual Safety Association, Boston, Statler Hotel.
APRIL 4- 5	Industrial Accident Prevention Association, Toronto, Canada, Royal York Hotel.
4- 7	American Petroleum Institute, Refining Division, Mid-Year Meeting, Houston, Shamrock Hotel.
11-12	American Institute of Electrical Engineers, New York, Statler Hotel.
11-13	Midwest Gas Association, Annual Convention, Des Moines, Hotel Ford Des Moines.
11-13	American Society of Lubrication Engineers, Annual Meeting, New York, Pennsylvania Hotel.
11-13	National Association of Corrosion Engineers, Cincinnati, Netherlands-Plaza Hotel.
11-15	Western Metal Congress and Exposition, Los Angeles, Shrine Civic Auditorium.
12-14	Southwestern Gas Measurement Short Course, Norman, University of Oklahoma.
13-15	National Petroleum Association, Cleveland, Hotel Cleveland.
18-20	Midwest Power Conference, Annual Meeting, Chicago, Hotel Sherman.
20-22	Southern Gas Association, Annual Convention, Biloxi, Buena Vista Hotel.
20-22	Natural Gasoline Association of America, Fort Worth, Texas Hotel.
APRIL 28	Society of Automotive Engineers, New York, Engineering Societies Building.
MAY 2- 4	Independent Petroleum Association of America, Mid-Year Directors Meeting, New Orleans.
2- 4	The American Society of Mechanical Engineers, Spring Meeting, New London.
8-12	American Institute of Chemical Engineers, Regional Meeting, Tulsa.
9-10	American Petroleum Institute, Division of Marketing, St. Louis, Jefferson Hotel.
9-10	American Gas Association, Natural Gas Department, Spring Meeting, French Lick, French Lick Springs Hotel.
9-11	Liquefied Petroleum Gas Association, Annual Convention and Trade Show, Chicago, Palmer House.
10-12	Interstate Oil Compact Commission, Jacksonville, Roosevelt Hotel.
12-13	Instrument Society of America, Annual Spring Meeting, Toronto, Canada, Royal York Hotel.
12-13	American Gas Association, Executive Conference, San Francisco, Fairmount Hotel.
16-19	National Fire Protection Association, San Francisco, Fairmont Hotel.
16-20	Oil Heat Institute of America, Annual Meeting, Boston, Statler Hotel.
17-19	Pennsylvania Gas Association, Annual Convention, Wernersville, Galen Hall.
23-25	American Gas Association Production and Chemical Conference, New York, Hotel New Yorker.
26	Society of Automotive Engineers, Diesel Engine, New York, Engineering Societies Building.
26-27	The Natural Gas and Petroleum Association of Canada, Annual Meeting, London, Ontario, Hotel London.
30 to June 1	Fourth Annual Short Course in Gas Technology, Kingsville, Texas, A & I College.

New Delhi plant makes the most OF COMPRESSOR POWER

Another Example of Efficient Power at Lower Cost



Automatically controlled at this new plant in the Delhi field, these four Cooper-Bessemer 1000 hp GMVs each have 5 compressor cylinders for 3-stage compression from 10 inches vacuum to 550 psi. Plant is now processing some 14 million cu. ft. of gas daily from 350 wells.

with

GMV Automatic Control

About 14 million feet of gas is processed daily . . . and with exceptionally high recovery of hydrocarbons . . . at a new natural gasoline plant in the Delhi field of Louisiana. The plant construction and operation is under the supervision of the Sun Oil Company.

This capacity is reached with only four 1000 hp Cooper-Bessemer GMV compressors . . . and will soon be increased by the addition of a fifth unit, bringing the plant total to 5,000 GMV horsepower.

Here, as in many other GMV installations, automatic control greatly simplifies the operation. Engine speed is automatically adjusted by speed and pressure controls for continuous output at maximum capacity as influenced by gas supply. Yes, the operators are making the most of compressor capacity.

As you plan your future operations, it might pay you to look into the features that have been developed for the automatic control of Cooper-Bessemer V-angles — new, often exclusive features that broaden control limitations and provide for greater-than-ever economies. But back of it all, remember, these modern units have the wide flexibility, dependability, and smooth running characteristics that are *first* essentials to success in automatic operation.

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speaker to be announced, and "Maintenance-Shop Layout and Tools," C. L. Haynes, C. F. Braun Company, Alhambra, Calif.

Thursday, April 7—**Waste Disposal.** Sponsored by the Committee on Disposal of Refinery Wastes. Four papers are scheduled but their authors have not been announced.

Meetings of the various API committees are scheduled during the regular sessions of the four-day meeting.

API Picks West Coast For 1950 Annual Meeting

Los Angeles was chosen for the 1950 annual meeting of the American Petroleum Institute, this action being taken by the board of directors last month at San Francisco. It also was decided to review the entire structure of the API and a committee will be named by President William Boyd for this purpose.

The study of the API, authorized by the board, will include basic policy, emphasis to be given the Institute's regional organization, etc.

The 1949 annual sessions are set for Chicago, November 7-10. Los Angeles dates are November 13-16, 1950. This will be the first West Coast meeting of the Institute since 1941 when the annual meeting was held in San Francisco. The last previous meeting in Los Angeles was in 1935. Last year more than 5200 attended the 28th annual meeting in Chicago.

P. E. Lakin, Shell Oil Company executive vice president, was named to the API board.

H. W. Fisher Is Deputy Coordinator for Standard

H. W. Fisher, a director and general manager of East Coast refineries of Esso Standard Oil Company, effective February 1, became deputy coordinator of refining activities for Standard Oil Company (New Jersey).

Fisher

Fisher, whose entire business career has been with affiliates of Jersey Standard, joined the organization 21 years ago, immediately after he was graduated from the Massachusetts Institute of Technology with a degree in chemical engineering. Much of his career has been devoted to the development and production of chemicals from petroleum.

Colorado Engineers' Day

The fifteenth annual Engineers' Day, to be held at the Colorado School of Mines, Golden, on April 22-23, will feature technical session in geology, geophysics, mining, metallurgy, petroleum production and petroleum refining as well as industrial and governmental exhibits.

Trends of Operations and Changes in Stocks

Figures on crude stocks are from Bureau of Mines weekly reports; all others from American Petroleum Institute weekly reports, which are estimates on Bureau of Mines basis.

(All figures in thousands of barrels—add 000)

Trends in Week Ended	Crude Oil			Gasoline		Gasoil and Distillate		Residual Fuel	
	Production Daily	Runs to Stills Daily	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End	Production Weekly	Stocks Week End
1948:									
January 31	5,318	5,434	221,663	15,986	102,973	7,090	40,580	9,141	50,839
February 28	5,387	5,463	220,507	15,796	111,040	7,963	33,836	8,824	49,206
March 27	5,377	5,324	222,814	15,783	112,991	7,682	30,717	8,854	48,334
April 24	5,415	5,517	221,652	16,515	111,128	6,831	34,237	8,877	49,572
May 29	5,452	5,715	221,703	17,827	107,185	7,054	38,641	9,508	55,149
June 26	5,494	5,674	222,081	17,938	104,178	7,300	45,166	8,858	56,812
July 31	5,455	5,718	223,137	17,646	99,116	6,823	56,661	9,080	65,713
August 28	5,529	5,682	222,170	17,722	95,504	7,491	66,321	8,818	70,853
September 25	*5,343	4,789	*226,072	15,100	78,669	5,997	61,884	6,380	37,326
October 30	5,604	5,626	230,633	17,569	91,925	7,679	81,593	8,853	81,299
November 27	5,617	5,721	234,585	17,317	93,802	7,476	85,151	9,477	86,192
December 25	5,641	5,784	240,648	18,178	100,286	7,776	79,271	9,121	86,181
1949:									
January 29	5,493	5,490	246,084	17,531	114,677	7,547	67,432	8,178	84,462
February 26	5,401	5,412	†259,554	17,621	124,382	7,430	57,746	8,225	80,246

* Total U. S. All other September 25 figures do not include California, due to strike.
† February 19 stocks, and include California heavy crude.

Odorization Regulation Lifted for LPG Items

Mandatory odorization of liquefied petroleum gases by the manufacturer will no longer be required under the specifications of the Natural Gasoline Association of America, according to William F. Lowe, secretary of the organization. One of the principal reasons for the move was said to be the diversified use for liquefied petroleum gases for industrial uses. Industrial uses are as raw materials or in processing of other products and the presence of an odorant often makes the gases undesirable.

McNulty to Husky

John R. McNulty has resigned as division director of personnel with The Ohio Oil Company at Casper, Wyo., to become manager of industrial relations for Husky Refining Company at Cody, Wyo. He had been with Ohio for 15 years.

A member of the Wyoming bar, McNulty is president of the recently organized Rocky Mountain Refiners' Association.

Gas Short Course

With the Southern Gas Association as sponsor, Texas A. & I. College, Kingsville, will present its fourth annual short course in gas technology May 30 through June 1. C. R. Williams of the Chicago Corporation, Corpus Christi, Texas, is chairman of the advisory committee. Dr. Frank H. Dotterweich, A. & I. engineering division director, is administrative committee chairman.

Engineers Complete Plans

The Engineers' Council of Houston will discuss "Conservation of Our Natural Resources" at its second annual symposium April 2 at the Rice Hotel in Houston. Papers will be presented by Paul Weaver, president of American Association of Petroleum Geologists, "Conservation of Water"; Dr. W. A. Albrecht, chairman of the department of soils, University of Missouri, "Conservation of Soil"; Eugene Ayres, Gulf Research and Development Company, "Conservation of Major Sources of Energy"; Dr. Sam L. Joekel, The Austin Presbyterian Theological Seminary, "Conservation of Character of Man"; and Louis Bromfield, author, "Conservation of Man."

Western Refiners Convene This Month in San Antonio

Western Petroleum Refiners Association, which convenes in San Antonio March 28-30 for its thirty-seventh annual meeting, will hear six important technical papers, as well as addresses by L. C. Allman, vice president of Fruehauf Trailer Company, and Ernest O. Thompson, member of the Texas Railroad Commission.

Technical papers follow:

"Hydroforming and Thermal Reforming Operations on Sweet and Sour Straight-Run Naphthas," N. H. McLaurin, The Texas Company, Port Arthur, Texas. (C. H. McIntosh and D. S. Kaufman, The Texas Company, collaborators.)

"Research and Development of Special Petroleum Products for the Air Forces," Lt. Col. H. A. Meesman, U. S. Air Force.

"Development of Fuels and Lubricants for Jet-Propelled Aircraft," Capt. Leslie G. Pattillo, U. S. Air Force.

"Various Refinery Applications of Houdriflow Catalytic Cracking," Dr. C. C. Peavy, Houdry Process Corporation, Philadelphia. (Messrs. Weinrich and Hornaday of the Houdry staff, collaborators.)

"Investigation of Distillate Fueloil Stability," R. O. Bender, E. I. du Pont de Nemours & Company, Wilmington, Del.

"Trends in the Refining Industry," Edwin F. Nelson, vice president, Universal Oil Products Corporation, Chicago.

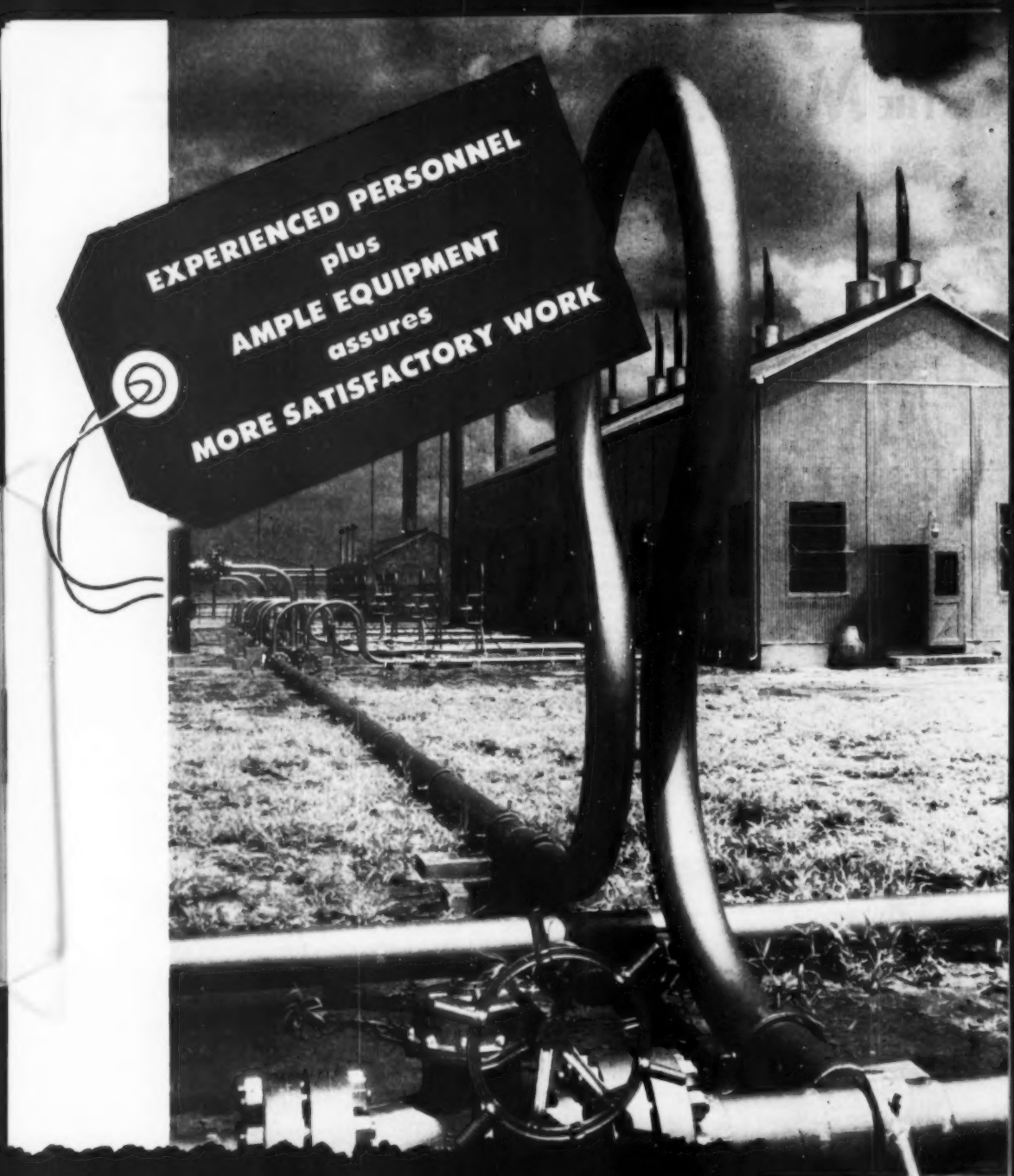
The Ethyl Corporation will be host at a buffet supper on the first evening of the meeting, the service and supply men will sponsor an informal party on March 29 and the association's annual dinner dance will be held on the final evening.

Headquarters will be at the Plaza Hotel.

Synthetic Plants Proposed

The possibility that the government might operate synthetic fuels plants as well as build them was presented last month in a report to the Joint Congressional Economic Committee by Dr. John W. Clark, a member of the President's council of economic advisors. "Where technological progress in perfecting methods of producing synthetic fuels are too slow to promise a flow of needed goods as quickly as they are needed, it is felt that the government would be justified in taking direct action to hasten the technical experimentation and in assuming the risks of constructing commercial plants before private capital would feel it justified," he declared.

President Truman has asked Congress to launch a federally-sponsored commer-



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THE MONTH . . .

cial synthetic liquid fuels production program with a direct appropriation of $1 million plus "contract and other authorizations" totaling $30 million.

Aim of the program, the President said, "is to provide financial assistance for the production. The country must face the fact that a major portion of its increasing energy requirements is being met by oil and gas, which actually constitute only a small portion of our energy. Dependence on foreign sources of oil are the prospects unless appropriate action is taken."

New Company Formed for Process Engineering Work

A new company, Rust Process Design Company, has been formed to take over the expanded activities of the process engineering division of The Rust Engineering Company, Pittsburgh. Named to an executive committee were Walter L. Bass, Dr. John A. Patterson, Leonard A. Wasselle and Dr. Wendell W. Waterman.

The company was set up to handle contracts for design, engineering and construction in the petro-chemical and organic chemical fields. It will also continue as an authorized engineer-constructor for units producing ethylene and aromatics by the thermofor pyrolytic cracking process of Socony-Vacuum Oil Company, Inc.

Americans to Read Papers At Technical Congress

U. S. engineers, who will deliver papers at the Second International Technical Congress in Cairo, Egypt, March 20-26, include W. H. Carson, Dean of the School of Engineering, University of Oklahoma, official delegate representing the Engineers Joint Council; Morris L. Cooke, Philadelphia management engineer and government consultant; and James S. Thompson, vice chairman of the board, McGraw-Hill Book Company, Inc. Max Thornburg of the Council's Middle East commission will attend as a delegate.

The Congress will be devoted to the "discussion of technical and social problems which are of primary importance to the consolidation of peace." Theme is "Raw Materials as an Industrial and Social Problem."

DuPont Promotes Puckett

Afton D. Puckett has been promoted to district laboratory coordinator in the petroleum chemicals division of E. I. DuPont de Nemours and Company, Inc. John N. C. Cameron has been named manager of the division's Gulf Coast district laboratory at 4141 Dennis Street, Houston.

Formerly Puckett was in charge of studies of antiknock properties of motor fuels in the company's combustion engineering laboratory at Deepwater, N. J.

Cameron comes to DuPont from Humble Oil & Refining Company where he engaged in octane rating and light oil analytical research and pilot scale research on catalytic treating.

Meserve Named Chairman, Darnell Fluor President

Shirley E. Meserve has been elected chairman of the board of directors of

Darnell

Fluor

Fluor Corporation, Ltd., Los Angeles. He has been general counsel for the company since 1929 and its president since 1947. He is also senior partner of the law firm, Meserve, Mumper and Hughes.

Succeeding Meserve as president is Donald W. Darnell. Joining Fluor in 1925 as an engineer, he has since served as chief engineer, vice president and general manager.

J. S. Fluor, Jr. has returned to the company, being elected executive vice president. Connected with the development and management of Fluor since 1921, he has been away from the company since 1946.

As a result of the reorganization of the company into two major divisions, W. Earl Dunn, formerly vice president, has been named vice president and general manager of the engineering and construction division; and J. Robert Fluor, formerly vice president and assistant general manager, has been named vice president and general manager of the manufacturing division.

Richmond Refinery Slated For Lake Maracaibo

Richmond Exploration Company, wholly owned subsidiary of Standard Oil Company of California, is planning to construct a refinery on Lake Maracaibo, Venezuela. Daily capacity will be approximately 35,000 barrels. Engineering work is now under way, although no contract has been let for the actual construction. Completion is scheduled for June, 1950.

Magnolia to Operate Joint Gasoline Plant

Magnolia Petroleum Company has awarded a contract to Jones and Laughlin Company, Tulsa, for the construction of a natural gasoline plant in the Sholem Alechem Field in the eastern part of Stephens County, Okla. The plant will be about two miles southwest of Tussy, Okla., and is expected to be completed by January, 1950.

Initial installation of compressors will process 22 million cubic feet of casinghead gas per day and the plant is designed for the ultimate processing of 30 mmcf. daily.

Besides manufacturing natural gasoline, the plant also will make butane and propane. It is designed for a total production of approximately 75,000 gallons per day of liquid hydrocarbon products. All residue gas not used for plant and lease fuel will be sold for pipe line transportation to commercial markets.

The project is a joint operation, with Magnolia as the plant operator, Amerada Petroleum Corporation, Stanolind Oil & Gas Company, Atlantic Refining Company, Alma Oil Company, Champlin Refining Company, Eason Oil Company, Republic Natural Gas Company and Wave Exploration Company. The individuals are Walter Duncan, Oklahoma City; W. J. Hunter, Shreveport, La.; Edwin L. Cox, Dallas; L. W. Winkler, Denver, Colo., and Paul F. Brennan, E. W. Hamilton, Frank B. Murta, J. E. Tomaney and Robert Wilson, all of Tulsa.

First Catarole Furnace Goes on Stream in England

At its Partington, England, plant, Petrochemicals Ltd. has placed on stream its first cracking furnace employing the Catarole process. Of British invention, the process is claimed to be the first of its kind to be developed.

In the process "an essential non-aromatic charging stock derived from petroleum is converted into the full range of aromatic hydrocarbons and into gases rich in olefins."

Petrocarbon Ltd. designed, constructed and erected the pilot plant as well as the large-scale plant.

Stacey-Dresser to Build Plant Near Stinnett, Texas

Plant construction will start early next month on an automatic "Desulfo" plant to be built by Stacey-Dresser Engineering Division, near Stinnett, Texas, for Panhandle Producing Company, officials announced last month.

The plant, with a potential capacity of 2750 mcf. per day, will automatically remove excess hydrogen sulfide from sour gas by an ethanolamine solution which flows through an absorber and a regenerator in a closed system. Sour gas enters the absorber, where the hydrogen sulfide is transferred to the amine solution. Regeneratjon of the amine is accomplished by stripping, using a small part of the sweet gas for the re-boiler. The hydrogen sulfide is then vented to the atmosphere. No utilities are needed except for occasional water and amine makeup, and supervision and maintenance work is practically eliminated, Dresser officials said.

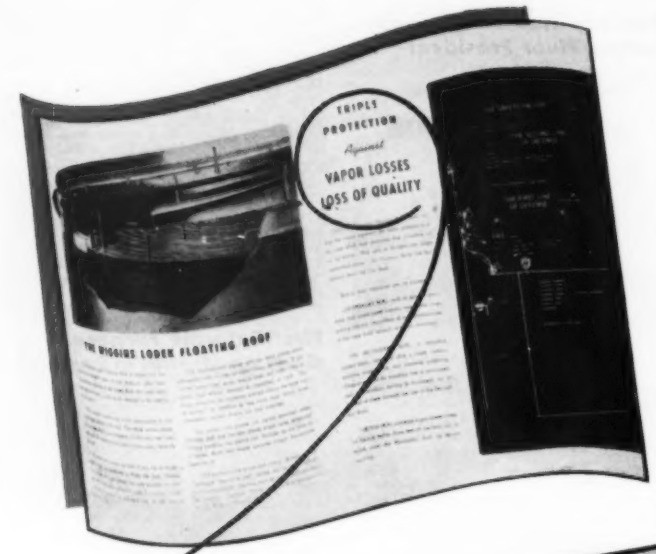
Desulfo plants are built in four standard sizes and are capable of processing gas which contains up to 1500 grains of hydrogen sulfide per 100 standard cubic feet.

Imperial to Build in Leduc

Imperial Oil Company will start construction soon on a gas-gathering system, compressor station and gasoline plant in the Leduc field of Canada. With a daily capacity of 24 million cubic feet, the plant will recover propane, butane and natural gasoline. Estimated cost is $6½ million with completion set for middle 1950.

Refinery for South Africa

Union Petrol Refinery, Ltd. has been organized in the Union of South Africa in an effort to reduce the importation of refined products. The company is



The Wiggins Lodek Floating Roof

. . . designed specially for the storage of corrosive oil products. The entire under surface being in complete contact with the tank contents, no vapors are trapped or can collect beneath the roof.

The basic exclusive conservation features of the Hidek Roof including the triple seal and extra large pontoons are retained.

Write for bulletin FR-3 which gives further details on Wiggins Lodek Floating Roofs.

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Hidek Floating Roof
Dry Seal Lifter Roof
Improved Breather Roof
Lodek Floating Roof
Dry Seal Gasholder
Improved Balloon Roof

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GREAT BRITAIN: Motherwell Bridge & Engineering Co., Ltd., Scotland
FRANCE: Etablissements Delattre & Frouard réunis, Paris
CANADA: Toronto Iron Works Ltd., Toronto

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planning to construct a refinery at a coastal port in the Union. Officers of the organization are listed in Johannesburg. Cost of the proposed refinery is estimated at $20 million.

Plans are also under way for the construction of a plant by Anglo-Transvaal Consolidated Investment to convert coal to liquid hydrocarbons. Hydrocarbon Research, Inc. has been awarded the contract for the engineering of this plant.

Standard Acquires Interest In Italian Oil Refineries

Standard Oil Company (New Jersey), has signed agreements to acquire 50 percent interest in a new company that will own and operate oil refineries at Leghorn and Bari, Italy, having a combined capacity of about 16,000 barrels of crude oil daily. Sharing the other half of the new company will be ANIC (Azienda Nazionale Idrogenazione Combustibili), present owners of the refineries whose stock is all Italian-owned.

The properties to be acquired by the new company are currently valued at $12 million. Plans are being studied for modernization of the facilities of both refineries. Both plants have been rehabilitated and the combined capacity increased to the present rate, utilizing Middle East crude oil. The refinery output will be marketed in Italy through SIAP, the Italian affiliate of Jersey Standard.

Caltex Buys Interest in Italian Oil Properties

California Texas Company, Ltd., has reached agreements with Fiat Company of Turin, Italy, to build a new refinery and join forces in marketing oil products. Caltex has agreed to buy an interest in Petrola S. A., a marketing company in Italy owned by Fiat. The name of the company will be changed to Petrolcaltex.

A 10,000-barrel capacity refinery will be constructed in the Po Valley, Italy, through an operating company, Sarpom. Arabian crude oil will be piped from a terminal near Genoa.

Anglo-Iranian Planning To Repair German Plant

The refinery of Europaeische Tanklager and Transport A. G. in Hamburg, Finkenwerder, Germany, has been acquired by Anglo-Iranian Oil Company, Ltd. Previous owner was Davies and Company, Inc., a United States firm which held the property through a British company.

Although the plant was damaged during the war, the distillation unit with a 3600-barrel capacity is expected to soon be repaired and ready to process imported crude.

Gas Measurement Course

The 1949 Southwestern Gas Measurement Short Course will be held at the University of Oklahoma, Norman, April 12-14. Specialized classes will include all

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phases of gas measurement regulation and related work. C. T. Chenery, chairman of the board, Southern Natural Gas Pipe Line Company, will deliver the principal address. Manufacturers will have educational exhibits for the course and prizes will be awarded to those writing best papers on "What I Learned at the Gas Measurement Short Course."

Bean Named Head of Stanton Manufacturing

Tilford H. Bean has been appointed manager of manufacturing for Stanton Chemicals, Inc. and will be in charge of the company's new plant nearing completion at Corpus Christi, Texas.

Bean

A graduate of the University of Texas with a degree in chemical engineering, he has worked with The Dow Chemical Company, The Rubber Reserve Corporation and Blaw-Knox Company. For several years he was associated with Firestone Tire and Rubber Company as chief engineer at its synthetic rubber development at Port Neches, Texas, as well as project engineer for its rubber products division at Paterson, N. J. Recently Bean has served in a consultant capacity, with Dallas offices.

VerMilyea to La Gloria For Head Purchasing, Traffic

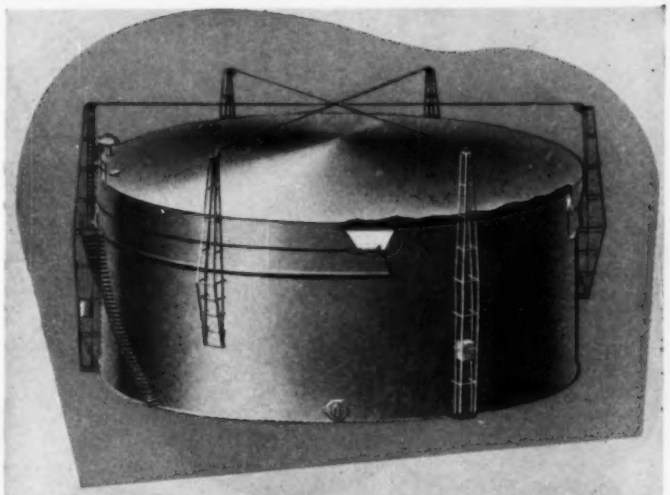
Victor VerMilyea has joined La Gloria Corporation, Corpus Christi, Texas, and will head the purchasing and traffic departments.

VerMilyea

First connected with the petroleum industry in 1933 when he was employed in the laboratories of United Refining Company, Warren, Pa., he was promoted to purchasing agent and assistant to the production manager in 1940. In 1945 VerMilyea transferred to Ashland Oil and Refining Company where he was employed as administrative assistant in the purchasing department, the position he held at the time of his new appointment.

International Develops Ductile Cast Iron Product

A new engineering material described as ductile cast iron, which combines the process advantages of gray cast iron with the product advantages of cast steel, has been developed by International Nickel Company. The material is characterized by a graphite structure in the form of spheroids, free from



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THE SEAL	1 — 100% dry seal eliminates corrosion, heating and freezing problems. 2 — No maintenance other than periodic inspection required. 3 — No possibility of stored product being absorbed in seal and creating a fire hazard. 4 — Out-of-level tank grade does not affect seal operation.
COUNTER BALANCE SYSTEM	1 — Reduces operating pressure to 1¾" water. 2 — Reinforcement of interconnected tanks not required. 3 — All mechanism completely accessible from outside. 4 — Not affected by out-of-level tank grade. 5 — No lubrication required.
PRESSURE VACUUM RELIEF	1 — No leakage, absolutely gastight. 2 — All working parts outside tank and readily accessible for inspection. 3 — Simplicity. Single valve serves for both pressure and vacuum relief.

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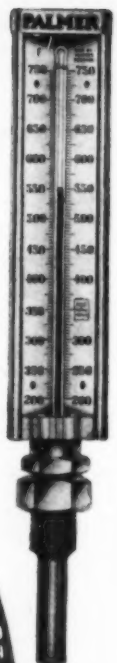

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THE MONTH...

graphite in the flake form. Physical properties include high elastic modulus, high yield strength and ductility.

Production of this iron can be applied to common cast iron compositions melted in the cupola or other kinds of furnaces and is based on the introduction into the iron of a small amount of magnesium or a magnesium-containing addition agent.

It is operative with practically all the basic types of cast iron.

Hudson Gets Contract

Hudson Engineering Company, Houston, has been awarded the contract for construction of a compression and absorption natural gasoline plant Humble Oil & Refining Company is planning in the Imogene-Jourdanton-Charlotte area of Atascosa County, Texas. Daily capacity will be 26 million cubic feet. Completion is scheduled for early 1950.

Goldsmith and Meisenburg Are Promoted by Shell

L. R. Goldsmith, superintendent of Shell Oil Company's Wilmington-Dominguez, Calif., refinery has been

Goldsmith

Meisenburg

transferred to the company's head office in New York. His new assignment will be in the economic development department, headed by N. J. McGaw, vice president. Goldsmith received his petroleum engineering degree at the University of California, and has been with Shell since 1932, in the manufacturing department. During the war, he spent two years in Washington, in the refining division of PAW.

S. J. Meisenburg will replace Goldsmith as refinery superintendent. A chemical engineering graduate of the University of Michigan, he started his Shell career in 1935 as a research engineer in the Wood River refinery. He has had extensive experience in Shell's Eastern refineries, and has recently been assistant manager of research and development in the New York office.

E. C. Peet Named Financial Executive for Shell Oil

E. C. Peet, formerly vice president and treasurer for Shell Oil Company east-of-the-Rockies, has been named financial vice president in charge of the company's financial organization from coast to coast.

Other changes in the Shell financial

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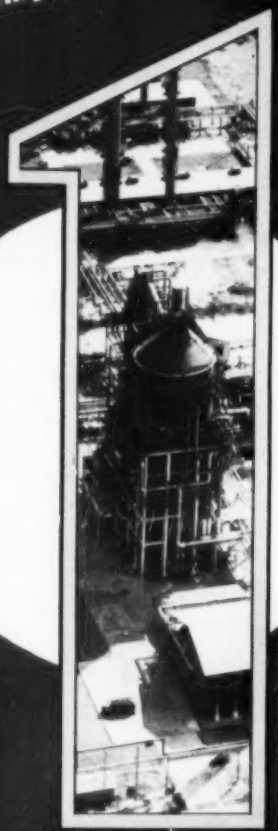

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THE MONTH . . .

organization result in J. H. White, vice president in San Francisco, moving to New York as vice president and controller, and A. G. Schei, treasurer of Shell Chemical Corporation, becoming treasurer of Shell Oil. White will have responsibility for all accounting, auditing and tax functions and Schei will supervise banking, credits, insurance, payrolls and office services.

A. A. Buzzi, formerly assistant treasurer, has been named assistant controller, and J. M. Flaherty, formerly manager of the accounting department, becomes assistant treasurer.

Dr. T. W. Evans Named Shell Research Director

Dr. Theodore W. Evans has been named director of research for Shell Developtment Company, effective March 1. He will be in charge of the operation and research program of the company's Emeryville, Calif. laboratories.

Evans

Joining the Emeryville staff in 1930 as a research chemist, he was active in the early development of alcohols, ethers and esters from refinery cracked gases and in the development of the solvent extraction theory. During the rubber shortage his studies led to early supplies of synthetic rubber by an exclusive Shell process. Dr. Evans was appointed an associate director of research in 1942 and has been manager of the laboratories since 1947.

He attended the College of Puget Sound and in 1930 he completed graduate work in chemistry at the University of Washington.

Bruno Stolley, former assistant manager of personnel for Shell Oil Company in New York, will succeed Dr. Evans as manager of the laboratories He will assist Dr. Evans by assuming responsibility for the administrative management of the laboratories.

Curtis Is Named Head of General Petroleum Plants .

James H. Curtis, manager of General Petroleum Corporation's Torrance (Calif.) refinery, has been appointed manager of refineries in the company's manufacturing department and will have general supervision of all General Petroleum refining operations.

Succeeding Curtis as manager of the Torrance refinery is A. E. Thompson who has been assistant manager.

Randal Maass, refinery engineer at Torrance, becomes assistant manager.

Curtis came to General Petroleum in December, 1942, from The Lummus Company, where he was a process engineer. He became assistant manager at Torrance in 1944 and manager in 1945.

Thompson and Maass both joined General Petroleum in 1934.

Sour Crude Subject for ACS Division Symposium

Sour crude oil will be the subject of a two-day symposium to be held by the Petroleum Division in connection with the 115th national meeting of the American Chemical Society in San Francisco March 28 to April 1. Dr. Arlie A. O'Kelly, vice chairman of the division and associate director of Socony-Vacuum Oil Company's research and development department, will preside. The theme will be "Organic Sulfur Compounds as Related to Petroleum." Papers include:

"Thermodynamic Properties of Sulfur Compounds," Kenneth S. Pitzer and Gordon M. Barrow, University of California; "Effect of Sulfur on Combustion of Leaded Gasoline," H. K. Livingston, J. L. Hyde and M. H. Campbell, Jackson Laboratory, E. I. DuPont de Nemours and Company, Inc.; "Catalytic Desulfurization of Crude Oil," J. H. Hale, M. C. Simmons and F. P. Wisenhunt, U. S. Bureau of Mines Petroleum Experiment Station; and "The Separation of Sulfur Compounds by Adsorption on Silica Gel," F. A. Fidler, R. A. Lowry and Mrs. D. Haresnape, Anglo-Iranian Oil Company, Ltd., Sunbury-on-Thames, Middlesex, England.

The petroleum division will join the division of analytical and micro chemistry in another two-day symposium, "Micro Chemistry and the Petroleum Industry." Harry Levin, supervisor of the analytical and testing department of the Beacon research laboratories of The Texas Company, will preside. Papers include: "The Micro Determination of the Knock Characteristics of Motor Fuels," J. Alexander, Jr. and C. Pfeiffer, Houdry Process Corporation; and "Micro Determination of Chemical Hazards in the Petroleum Industry," Morris B. Jacobs, Polytechnic Institute of Brooklyn.

Reports on shale oil refining will be given at a special session of the petroleum division, which is also sponsoring a high polymer forum under the chairmanship of Dr. William J. Sparks, director of the chemical division of Standard Oil Development Company.

Five AICE Sections Plan Symposium for This Month

The Akron, Cleveland, Pittsburgh, Ohio Valley and Central Ohio sections of the American Institute of Chemical Engineers are sponsoring a symposium, "Operations and Equipment Costs," in Columbus, Ohio, on March 18.

Morning speakers include E. C. Dybdal, Monsanto Chemical Company, "Engineering and Economic Evaluation of Projects at the Research Stage"; J. A. Flint, Jeffrey Manufacturing Company, "Efficient Conveying and Economical Crushing in Chemical Plants"; L. S. Stinson, Elliott Company, "Comparative Costs of Mechanical Vacuum Pumps and Steam Jet Ejectors"; and M. H. Bigelow, Libbey-Owens-Ford Glass Company's Plaskon Division, "Cost of Acetylene Production Based on the German Arc Process."

Blythe M. Reynolds, vice president of Merck and Company, will present "Economics of Chemical Plant Expansion" at a luncheon. Afternoon speakers include H. L. Barnebey, Blaw-Knox Company, "High Temperature Process Heating-Relative Costs"; F. W. Gilchrist, Toledo Scale Company, "Modern Industrial Weighing"; C. A. Rauh, Maurice A. Knight, "Cost of Protective Coatings and Plant Equipment"; and O. L. Barnebey, president of Barnebey Cheney Engineering Company, "Economics of Activated Charcoal Solvent Recovery."

Electrical Engineers Meet Scheduled at Buffalo

The American Institute of Electrical Engineers will hold a conference on the industrial application of electron tubes in the Statler Hotel at Buffalo, N. Y., on April 11-12.

Tentative papers include: Electronic D. C. Motor Control, Electronic Regulation and Regulating Systems, Electronic Control of A-C Power, Electronic Relaying Devices and Photoelectric Controls, The Adequacy and Inadequacy of Present Tube Ratings, The Need for Basic Tube Ratings, Ratings of Pool Tubes for Control and Rectification, Special Ratings for Mercury Vapor and Gas Tubes and The Meaning of Phototube Ratings.

Shell Appoints Wyman

Joseph B. Wyman has been appointed assistant superintendent of Shell Oil Company's Deer Park refinery, succeeding Roy W. Faulk who has been named assistant personnel manager of Shell's head office personnel department in New York.

Wyman

A graduate of Washington University, St. Louis, Wyman joined Shell in 1928 as an experimental junior chemist at the company's Wood River Refinery near St. Louis. He was named assistant to the head stillman and stillman in charge of cracking in 1932, and, five years later, assistant general superintendent. Between 1947 and 1949, Wyman was on special leave of absence with an affiliated company, returning to Shell's Houston refinery recently to assume his present responsibilities as assistant superintendent in charge of cracking, topping dispatching and gas.

Foster Snell Wins Medal From Chemical Group

Foster Dee Snell, president of Foster D. Snell, Inc., has been named to receive the Society of Chemical Industry's gold medal for 1949. Presentation will be at the Society's meeting at Manchester, England, on July 13, when he will deliver an address on a phase of surface activity.

The medal is awarded bi-annually by the Society's council to a person "who has attained eminence in applied chemistry." The medal was first awarded in 1896 and has since been awarded to only one American, Professor Ira Remsen of Johns Hopkins University, in 1904.

DuPont Promotes A. F. Bowe

E. I. DuPont de Nemours and Company, Inc., has promoted Arthur F. Bowe to manager of the Eastern district laboratory of the petroleum chemicals division, serving the Atlantic Seaboard of the United States and Canada. The laboratory is one of five established last year to serve oil refiners in connection with their use of tetraethyl lead and other petroleum chemicals.

Shell Changes Offices

Shell Chemical Corporation has transfered its administrative offices from 4 West 58th Street, New York 19, to 50 West 50th Street, New York 20, effective February 1. The Eastern Division sales offices will continue to be located at 500 Fifth Avenue, New York 18 and the western division sales offices at 100 Bush Street, San Francisco 6. The offices of the export division are at 4 West 58th Street, New York 19.

REFINER AUTHORS and Other Personalities

Information, formal and otherwise, about the men who write for PETROLEUM REFINER as well as others prominent in the industry.

Cycle Washing Is Magnolia Topic

"CYCLE Washing of Percolation Filters," which begins on page 135 of this issue of PETROLEUM REFINER was prepared by two members of Magnolia Petroleum Company's technical staff—E. J. Reeves, supervisory process engineer, and R. E. Turkleson, process engineer, who are concerned with solvent dewaxing, wax manufacture, lubricating oil decolorization, and related problems in the Beaumont, Texas, refinery.

Reeves joined Magnolia in 1943 as a process engineer after receiving his degree in chemical engineering from Rice Institute. His work in the plant has included a variety of experience with waxes and lubricants, and a term with the Houdry catalytic cracking units. He is a member of American Chemical Society and its Petroleum Division. For some time Reeves has served on the staff of *The Condenser*, monthly publication of the Texas-Louisiana Gulf Section of the ACS, and on the local section's meeting arrangement committee. He is also an abstractor for *Chemical Abstracts*.

Papers published by Reeves include "Optimum Dilution in Viscous Liquid Filtration," *Industrial and Engineering Chemistry*; "Rotation Speed in Continuous Filter," PETROLEUM REFINER; "Effects of Solvent Composition and Primary Solvent Dilution on Dewaxing Filter Rates and Wax Oil Contents," PETROLEUM REFINER; and "Optimum Temperature Gradient in Selective Solvent Extraction," accepted by *Industrial and Engineering Chemistry*.

Reeves is the proud father of a year-old daughter, who demands and receives a large portion of his spare time.

R. E. Turkleson hails from his native state of Kansas. He returned to Kansas State College in 1946 to obtain a degree in chemical engineering after three and a half years in the army. He served as battery commander in an antiaircraft artillery unit of the Third Army in the European Theatre of Operations.

Since joining the technical staff of Magnolia Petroleum Company at Beaumont in November of 1946, he has been working in solvent refining, dewaxing, and decolorization of lubricating oils since that date.

The Turkleson family includes three young daughters, who reportedly do not fully approve of their father's hobby of amateur philately.

A Greasemaker Tells His Story

CHARLES J. Boner has completed 22 years of service with Battenfeld Grease & Oil Corporation, Kansas City, Mo., and for the past 14 years has directed the company's research program. His article, "Manufacture of Lubricating Greases" appears in this issue PR beginning on page 109. This is the first of a series of articles by a widely-known authority on this important portion of the petroleum industry.

Boner is a mid-western by birth and by education, having been born in Kansas and educated at the University of Missouri, from which he received his degree in chemical engineering.

He is an active member of the Amer-

• CONTINUED ON PAGE 180

Further Findings of Sonneborn Group

"LOW Temperature Flow Resistance Test for Lubricating Oils" by L. C. Borell and Gerald Coulter of the Franklin Refinery Division of L. Sonneborn Sons, Inc., is a description of the work the pair has done in the laboratory on this subject. The article begins on page 122 of this issue of PETROLEUM REFINER.

L. C. Borell, chemist of the Franklin Refinery Division, received his bachelor of science degree from Grove City College in 1928, and his master's degree from the University of Pittsburgh in 1932.

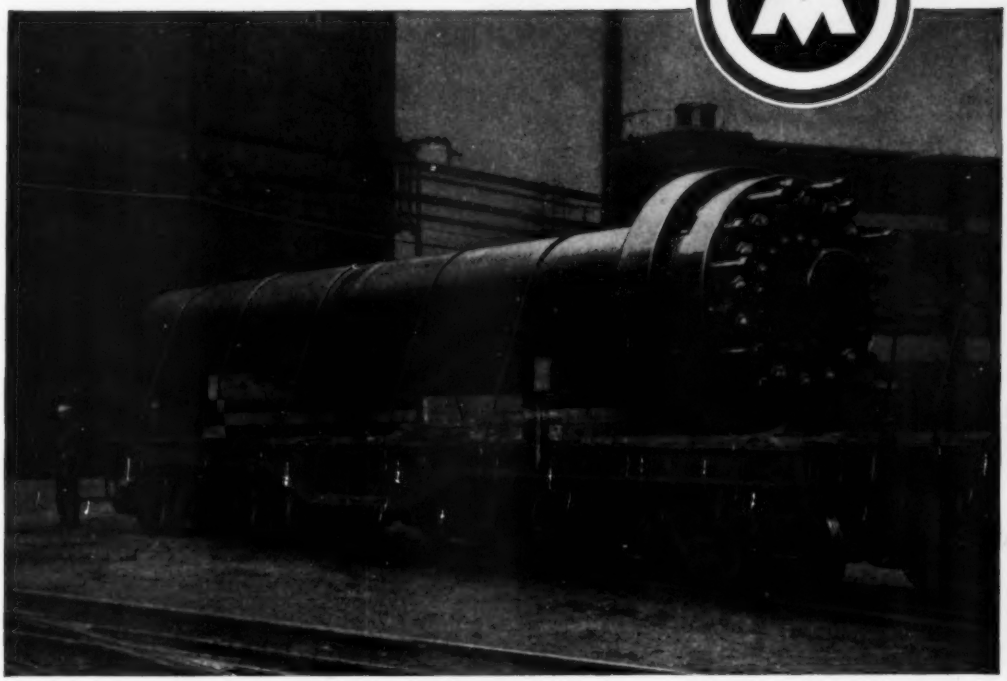
Soon after receiving his master's degree, Borell joined the staff of L. Sonneborn Sons, Inc. at the Petrolia Laboratory as research chemist. He has been at the Franklin plant since 1944.

The Borells and their 12-year-old daughter live on a 100-acre farm in the country. Borell spends his spare time with his family and supervising the operation of the farm. He indulges in a special hobby occasionally—woodworking. He is a member of American Chemical Society and Society of Automotive Engineers.

Gerald Coulter and Mrs. Coulter are the proud parents of a son who only recently was one year old. Coulter is a bachelor of science graduate, like Borell, from Grove City College, 1932. With the exception of two years in military service, he has been with L. Sonneborn Sons, Inc. for 13 years.

Number one hobby for Coulter is his family, but when time permits, he turns "ham" and tinkers away at amateur radio.

L. C. BORELL | GERALD COULTER | R. E. TURKLESON | E. J. REEVES



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C. J. BONER

M. E. GARRISON

Greasemaker

• CONTINUED FROM PAGE 178

ican Chemical Society, and has served as chairman of the Kansas City section. Also, he is a member of the staff of Chemical Abstracts. Believing to a great extent in the dissemination of scientific information, Boner likes to write and has written numerous articles for publication. He has contributed a chapter in Voume VI of *Alexander's Colloid Chemistry*, under the title, "Colloidal Characteristics of Lubricating Greases." One of his most recent contributions, "Barium Lubricating Greases" appeared in *The Institute Spokesman*, June, 1948, in conjunction with G. W. Miller, president of Battenfeld Grease & Oil Corporation of North Tonawanda, N. Y.

Although lubricating greases occupies the majority of his time, Boner reports that gardening comes next. Lesser interests include bowling and stamp collecting.

Sherwood Back with Second Contribution

PETER W. Sherwood makes his second contribution to PR under the title of "Ethylene Glycol by Air Oxidation of Ethylene," which begins on page 129 of this issue. His first article, "Acetylene From Petroleum Gases," appeared in the November, 1948, issue.

Sherwood completed his undergraduate studies and received his M.S. degree from Columbia University in chemical engineering, and has continued his graduate studies at Brooklyn Polytechnic Institute and the University of Pittsburgh. Something of a linguist, French, German and Spanish being his oysters, Sherwood also enjoys indulging in two other hobbies—golf and photography.

He has been associated with Koppers Company, Inc., in Pittsburgh, since 1943. Presently he is engaged as a process engineer concerned with technical and economic evaluation of various chemical processes and the design and estimating of chemical and fuel plants.

A Koppers fellowship at the Mellon Institute of Industrial Research was awarded to Sherwood. In 1945 he accompanied the Technical Oil Mission to Germany. As assistant chief of the fuels and lubricants unit of field information agency, he was provided with an unusual opportunity to study German synthetic and natural oil technology. Recently he published "High Pressure Hydrogenation in Germany," a monograph on German coal liquefaction technology.

Writes of Plant Which He Built

M. E. GARRISON, author of "General Petroleum Gasoline Plant Extracting 80 Percent Propane," beginning on page 153 of this issue of PETROLEUM REFINER, is a native of Golden, Colorado. He received his engineering training at the Colorado School of Mines.

Garrison went to work for General Petroleum Corporation in September, 1928—nine months later he was advanced to supervisor. In May, 1936, he became an assistant engineer, and in August, 1947, assumed the duties of project engineer. He is presently working at the company's Vernon, California, plant, and makes his home in Long Beach.

Holaday Selected

W. M. Holaday, director of research for Socony-Vacuum Oil Company, Inc., has been named chairman of the fuels and lubricants committee of the research and development board of the National Military Establishment. The committee will determine policies on research and development of fuels and lubricants "as may affect the National Military Establishment." Committee membership includes two other civilians and representatives of the three branches of the armed services.

California Standard Honors Veteran

E. D. Gray, assistant to the general manager of the Richmond refinery of Standard Oil Company of California, was honored recently a few days before his retirement after completing 50 years of service with the company. Congratulating Gray, who is third from the left, is A. C. Moorehead, personnel director of the manufacturing department. Looking on, left to right, are R. K. Rowell, refinery general manager; O. N. Miller, manager of the manufacturing department; G. A. Davidson, vice president of Standard; and F. H. Smith, general manager of operations.

SCIENCE and TECHNOLOGY Abstracts

Prepared by
DR. E. H. LESLIE and DR. H. B. COATS
The Leslie Laboratories
Traver Road, Ann Arbor, Mich.

These abstracts are selected from the current literature of science and technology, not including trade journals easily available. Photostatic copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, also will be prepared and furnished by arrangement with the Laboratories.

Products: Properties, Utilization and Analysis

Modern Petroleum Lubricants. A New Chemical Market. C. F. PRUTTON AND F. F. MUSGRAVE, *Chem. Eng. Progress* **45** (1949), pp. 17-24.

General subject of petroleum lubricants and the use of additives in them is described and discussed. Pioneering work in additives is described and why additives are needed and how they function are considered. Testing programs in additive development are briefly discussed as well as the test facilities that must be available. More research work on the fundamental aspects of lubrication and on the mechanism of lubricant and additive action is needed. It is concluded that new additives and refining procedures applied to petroleum stocks will continue to meet lubricating oil requirements for some time, although synthetic lubricants containing additives will probably be the ultimate development. It is believed that chemical additives for lubricants provide an important market for chemical products.

Emulsions of Seawater in Admiralty Fuel Oil With Special Reference to Their Demulsification. A. S. C. LAWRENCE AND W. KILLNER, *Jour. Inst. of Petroleum* **34** (1948), pp. 821-56.

Present-day fuel oils emulsify water readily and form mixtures of great stability, although this was not true of pre-war Armiralty fuel oil. The emulsion varies from wet oil, containing from 1 to 20 percent water, to real "sludge" that may contain up to the theoretical limit of 74 percent water. The problem of emulsification of seawater in Admiralty fuel oil is described, and the deleterious effects of these emulsions in ships and fuel oil depots are briefly indicated. The significant properties of the emulsions are described. A theory of emulsion stability is developed and, correspondingly, the conditions for demulsification are given. The emulsifying agent was found to be contained in the whole asphalt fraction of the oil, and it was demonstrated that this material is responsible. The mechanism of breaking the emulsions by addition of surface-active agents and by fluxing additives is described, as well as the conditions for the most efficient and proper use of the materials. Successful application of the method to large-scale trials on shore and at sea are recorded. A brief discussion indicates that the success of the work and of the theoretical approach upon which it is based challenge several basic conceptions of emulsions and demulsification that at present are generally accepted. A new sampling pot and a modification of the Dean and Stark apparatus designed for use at sea are described.

Vaporization of Liquid Hydrocarbon Mixtures into Air. GEORGE G. LAMB AND LEO J. O'BRIEN, *Ind. Eng. Chem.* **41** (1949), pp. 182-9.

A study was made of the equilibrium and rate phenomena associated with the vaporization of fuel prior to the combustion in an aircraft engine. The authors believe that the rate concept as represented by mass transfer between phases across a laminar film resistance presents a ready means of defining fuel vaporization in terms of fuel composition, time available for the change in state and the intensive factors affecting vaporization — i.e., pressure and temperature. Comparison was made between experimentally determined ASTM and theoretical batch differential distillations, calculated equilibrium air distillations and theoretical equilibrium flash distillations. The data are presented in graphical form and a bibliography of 36 references is included.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Regisrty.

1-Pentenyl-1-acetate
Vaccenic acid
2-hydroxy-1, 4-dimethylbenzene
4-Methoxycatechol
4-Phenoxycatechol
3,3',4'-Trihydroxydiphenyl ether
3,3',4'-Trihydroxydiphenyl
2,4,5,2',4',5'-Hexahydroxydiphenyl ether
2,4,5,2',4',5'-Hexahydroxydiphenyl
3,3',4,4'—Tetrahydroxydiphenyl ether
3,3',4,4'—Tetrahydroxydiphenyl
2-Ethoxyhydroquinone
2-Methoxyhydroquinone
2-Amino-4-nitrophenyl ethyl ether
2, 4-dimethyl-5-phenylthiazole
3-(Hydroxymethyl) indene
n-Docosanal
3-Hydroxyanthranilic acid
Perchloroethylene oxide
Dilauryl sulfide
Cyclooctatetraene

Oxidation of Pentane. The Oxidation, Ignition, and Detonation of Fuel Vapors and Gases. VII. The Oxidation of Pentane in Varying Concentration in Air at Temperatures Rising to 700 C. and the Effect of Iron Carbonyl on Reaction Velocity. R. O. KING, *Can. J. Research* (F) **26** (1948), pp. 426-40.

The tendency of a fuel-air mixture to detonate varies with the mixture strength. The oxidation characteristics of mixtures from 25 percent weak to 100 percent rich were determined using pentane and air. Oxidations were effected with and without additions of iron carbonyl to pentane for undoped mixtures at temperatures approaching those of the end gas in an engine. Reaction velocity increased by 100 percent when mixture strength was increased and by 100 percent when temperature was increased from 600 to 650° C. For the doped mixtures there was a definite increase in reaction velocity on increasing mixture strength. The oxidation of pentane over the temperature range of aldehyde formation is a heterogeneous reaction. This is probably true of oxidations at high temperatures. Thus pentane vapor can be exposed to any temperature up to 700° C. while reaction proceeds with high velocity to reach a limiting value, without the occurrence of ignition or explosion.

Aviation Fuels: The Development of Tests for Determining Rich-Mixture Performance. D. A. HOWES AND R. STANSFIELD, *Jour. Inst. of Petroleum* **34** (1948), pp. 857-77.

The paper records the work done at the Research Laboratories of the Anglo-Iranian Oil Company during the early part of the war which work helped both to develop satisfactory test procedures and to evaluate the anti-knock properties of fuels for use in aero-engines. A description of the C.R.C. F-4 Method of Test which is now in wide use is given, together with a discussion of the rating scales used. Properties of the isohexane and the isoheptane separated from Iranian crude oil are given. Data on the blending value of many hydrocarbons are included. Some data on the effect of sulphur content is given. The application of the

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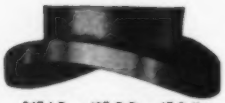

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- Billets to 14" diameter upset, forged and pierced.
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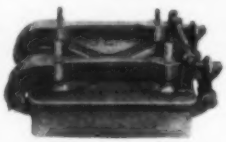

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work at the Abadan refinery is described. The maximum production of 100 octane number fuel was somewhat more than 8 percent of the crude oil processed and since there were no catalytic-cracking facilities in Abadan this was made almost entirely from the gasoline fraction of the crude. Fuels made were largely as blends of straight-run products with isoparaffins. Data are presented in some detail in tabular and graphical form and a bibliography of nine references is included.

Distillation. ARTHUR ROSE, *Analytical Chem.* **21** (1949), pp. 81-4.

The author reviews the literature on laboratory distillation for the period 1946 to 1948, inclusive. Material is presented under the headings: Utilization of Fractionation, Special Methods, Evaluation of Apparatus, Improvement of Apparatus, Development of Special Apparatus, Low Temperature Distillation, Application of Theoretical Concepts, Simple Distillation Procedures, European Advances, and Bibliographies. A bibliography of 154 references is included.

Silica Gel Fractionation of 300-Viscosity Lubricating Oil. R. R. HIBBARD, *Ind. Eng. Chem.* **41** (1949), pp. 197-200.

Making a study of the factors involved in the oxidation of lubricating oil, a careful chromatographic fractionation was run to resolve a 300-viscosity red oil into its hydrocarbon types. Many fractions were taken and physical and chemical properties determined for many of them. Blends containing 10 percent of the various aromatic fractions were run by the Sohio oxidation test and the tendencies of these fractions to form sludge, pentane insolubles and acids were related to hydrocarbon type. The apparatus used is described and secured in the course of the work is presented in some detail in tabular and graphical form. A bibliography of 11 references is included.

Chemical Composition And Reactions

Isomerization of Cyclohexenes to Cyclopentenes: Oxidation of These Alkenes to Glycols and Acids. HOMER ADKINS AND ALAN K. ROEBUCK, *Jour. Am. Chem. Soc.* **70** (1948), pp. 4041-5.

Cyclohexene is isomerized over pure alumina at 470-480° C. to methylcyclopentene-1 and -2. Methylcyclohexene-1 is isomerized over pure alumina to 1,2-dimethyl- and ethyl-cyclopentenes. The four cyclopentenes were isolated in yields that made them available for synthesis. The method of oxidation using hydrogen peroxide in formic acid has been used quite effectively for the conversion of cyclohexene, three isomeric methylcyclohexenes and four cyclopentenes to the corresponding glycols. These glycols were oxidized further with potassium permanganate or chromic acid to various dibasic and keto acids.

Studies in the Methylcyclopentane Series. II. Preparation and Reactions of Methylcyclopentenes. GARSON A. LUTZ, ARTHUR E. BEARSE, JOHN E. LEONARD AND FRANK A. CROXTON, *Jour. Am. Chem. Soc.* **70** (1948), pp. 4139-42.

The authors developed methods for the preparation of methylcyclopentenes from methylcyclopentane. A method is

described for the separation of 1-methylcyclopentene from mixtures of isomeric methylcyclopentenes. The dehydration of the isomeric methylcyclopentanols and the dehydrochlorination of the methylcyclopentyl chlorides were studied. It was shown that the cyclic olefin boiling at 75° C. obtained by dehydration of 3-methylcyclopentanol is 1-methylcyclopentene. Several new reactions of the methylcyclopentenes were studied and some new compounds in the methylcyclopentane series were synthesized.

The Thermal Decomposition of Cyclopentene. Don W. Vanas and W. D. Walters, *Jour. Am. Chem. Soc.* **70** (1948), pp. 4035-9.

The investigation reported was part of a general study of the thermal decomposition of alane compounds and was undertaken to obtain more information concerning the homogeneous thermal decomposition of cyclopentene in a static system. Studies were made in the temperature range 483-548° C. and at pressures from 38 to 249 mm. Determination of the cyclopentadiene and non-condensable gas in the products has shown that the principal reaction is the dehydrogenation of cyclopentene to cyclopentadiene and that during the early portion of the decomposition the pressure increase is a satisfactory indication of the extent of dehydrogenation. The reaction is apparently initially of the first order, but during a single run the value of the first order constant calculated from pressure measurements, is found to be not constant in the later stages of decomposition. The addition of propylene to cyclopentene does not appreciably alter the rate of pressure increase.

Manufacture: Processes and Plant

High Temperature Distillation. T. J. Walsh, *Ind. Eng. Chem.* **41** (1949), pp. 25-7.

The author reviews developments in the field of distillation, as one of the articles included in Industrial and Engineering Chemistry's annual Review of Unit Operations. Topics included are Industrial Distillation, Economic Column Design, Distillation Theory, Distillation Calculations, Laboratory Distillation Apparatus, Equilibrium Data, Correlations of Equilibrium Data, Extractive Distillation, and general discussions. A bibliography of 47 references is given.

Heat Transfer. George T. Skaperdas, *Ind. Eng. Chem.* **41** (1949), pp. 52-5.

The author reviews the work of 1948 on the subject of heat transfer under the headings boiling, condensation, convection, conduction and miscellaneous. The period covered by the review was marked by an increase in the proportion of papers on boiling. A bibliography of 58 references is given.

Solvent Extraction. Joseph C. Elgin, *Ind. Eng. Chem.* **41** (1949), pp. 35-8.

The article reviews the work done during 1948 on the subject of solvent extraction as applied to liquid-liquid systems. Subjects covered are phase equilibrium, solubility, laboratory extraction, equipment and performance, design, process methods, and data and applications. Many excellent design and operating data on existing commercial solvent extraction plants became available during the year. However, there is need for many more data, and, in particular, for studies of the factors determining the performance of continuous liquid-liquid contacting powers. A bibliography of 83 references is included.

Suspensoid Cracking Pilot Plant. J. W. Flanagan. *Ind. Eng. Chem.*, **41** (1949), pp. 211-15.

Suspensoid catalytic cracking is a simple and flexible procedure for the conversion of petroleum hydrocarbons to gasoline and other products. Natural or synthentic catalyst in an oil or water slurry is charged with the feed stock to the reaction zone of a conventional thermal cracking coil. The quantity of catalyst used varies 2 to 10 pounds per barrel of feed. A pilot plant of three gallons per hour capacity was constructed for the study of suspensoid catalytic cracking. The flow diagram is presented, equipment is described and the operating procedure is given. It was found that product yield and quality data from the pilot plant runs could be used to predict yields and product quality for runs made on commercial units.

Proposed Correlation of Data for Isothermal Two-Phase Two-Component Flow in Pipes. R. W. Lockhart and R. C. Martinelli. *Chem. Eng. Progress*, **45** (1949), pp. 39-48.

The authors present data for the simultaneous flow of air and liquids including benzene, kerosene, water and various oils in pipes varying in diameter from .0586 to 1.017 inch. Four types of isothermal two-phase, two-component flow are shown to exist depending upon whether each phase is flowing viscously or turbulently. The pressure drop resulting from these various flow mechanisms is correlated by means of parameter X equal to the square root of the ratio of the pressure drop in the pipe if the liquid flowed alone to the pressure drop if the gas flowed alone. Tentative criteria are proposed for the transition of the flow from one type to another. The per cent of pipe filled with liquid under any flow conditions is also shown to be correlated for all four flow types by means of the parameter X.

Organics From Natural Gas. J. V. Hightower, *Chem. Eng.* **56** (1949), Nol. pp. 92-4.

The plant of McCarthy Chemical Company of Houston, for the manufacture of methanol, formaldehyde and acetaldehyde by oxidation of natural gas components is described. The plant can handle up to 100 million cubic feet of gas per day. Scrubbed gas is heated in a gas-fired tubular heater to a temperature required for the reaction with oxygen in the oxidation reactor. Oxygen of 90 to 95 percent purity is used. The oxidation products are absorbed in water and residual gas enters the gas distribution system. The water solution is stripped of the oxidation products and the overhead is fractionated for the separation of formaldehyde, acetaldehyde and methonal. Some formaldehyde is produced by direct oxidation. The greater part is manufactured by oxidation of part of the methanol. Those parts of the plant in contact with formaldehyde are built in stainless steel.

Fundamental, Physical And Chemical Data

Equation of State. Generalized Correlation Applicable to All Phases. Wm. F. Rush and B. Wm. Gamson, *Ind. Eng. Chem.* **41** (1949), pp. 78-81.

Extensive work has been done in the past to develop an equation of state that would be applicable to all substances over a wide range of conditions. Until recently such equations of state were limited in their applicability to relatively narrow and restricted regions of temperature and pressure. Thus, the well-known Beattie-Bridgeman equation is useful for only a restricted region. Recently, McLeod developed a modified van der Waals equation of state of wide application. The authors present a correlation that permits the evaluation of the constants of the McLeod equation having only a knowledge of the critical constants of the substance. Use of Kay's pseudocritical concept permits extending the above correlation to mixtures. Good agreement is found with experimental values.

The Thermodynamic Properties and Molecular Structure of Cyclopentene and Cyclohexene. C. W. Beckett, N. K. Freeman and Kenneth S. Pitzer, *Jour. Am. Chem. Soc.* **70** (1948), pp. 4227-30.

The potential or restraining energy of cyclopentene and cyclohexene was calculated for various configurations by use of the bond bending and bond twisting potential constants from related molecules. It was found that cyclipentene can pucker by moving the carbon opposite to the double bond out of the plane of the other four carbon atoms by about 0.3 A. without significant change in energy from the planar configuration. Cyclohexene, in contrast, shows two tautomeric forms related to the chair and boat cyclohexane which differ by about 2.7 kcal. per mole. The available Raman and infrared spectroscopic data are interpreted for cyclopentene and cyclohexene. With reasonable adjustments of otherwise somewhat uncertain parameters, agreement was obtained with the thermodynamic data for the two substances. The thermodynamic functions were then calculated for the ideal gas state from 0 to 1500° K.

Calculation of Resonance Energies from Thermal Data. J. G. M. Bremner and G. D. Thomas, *Trans. Faraday Soc.* **44** (1948), pp. 338-41.

The Pauling and Kistiakowsky methods give different values for the resonance energies of aromatic compounds. This may be occasioned by the approximate nature of the Pauling bond energies. An alternative "group" rather than bond method is suggested by the authors for referring the aromatic series to the aliphatic series. This method gives resonance energies in good agreement with the Kistiakowsky values. Among the compounds studied were methane and the even-C n-paraffins from C_2H_6 to $C_{36}H_{86}$, benzene, m- and o-xylene, mesitylene, styrene, cyclohexane, and mono-substituted benzenes and cyclohexanes including methyl, ethyl, propyl, butyl, hexyl, octyl, decyl, dodecyl, tetradecyl, and hexadecyl.

Digest of Recent U. S. PATENTS Pertaining to PETROLEUM REFINING

Compiled by HEINZ HEINEMANN

(From the Official Gazette, December 14, 21, 28, 1948, and January 4, 1949.)

CRACKING AND REFORMING

U.S.P. 2,456,035. Treatment of Fluids with Cominuted Solids. B. F. Wobker to Phillips Petroleum Company.

In the continuous treatment of organic fluids with a finely divided solid contact material (e.g. in the catalytic cracking of hydrocarbons in the presence of fluidized catalyst) in a plurality of treatment-reactivation zones, the organic fluid to be treated is passed into one of these zones which contains a predetermined minimum amount of fluidized contact material. This amount is gradually increased from a storage zone while the organic fluid is passing the treating zone, the average percentage of carbon impurities on the contact material thus being minimized. The flow of fluid to be treated is diverted into another of the treatment-reactivation zones when the quantity of contact material in the first treating zone has increased to a predetermined maximum, and the treatment is continued in this second treating zone in the same manner. The contact material retained in the first treating zone is reactivated, and the amount of reactivated fluidized catalyst in this zone is then reduced to the predetermined minimum while the excess is transferred to the storage zone.

U.S.P. 2,456,351. Activation of Catalyst. A. B. Welty, Jr. and C. H. Holder to Standard Oil Development Company.

Hydrocarbons containing naphthenes are contacted at elevated temperatures and pressures with added hydrogen and a composite catalyst consisting of molybdenum oxide supported on a zinc aluminate spinel base and calcined at temperatures of about 1400° F. for about six hours. Virgin naphtha can be hydroformed by this process under formation of aromatic hydrocarbons.

U.S.P. 2,456,786. Heating of Hydrocarbon Fluids. L. Kniel, P. Lambert and H. R. Treat to The Lummus Company.

Hydrocarbon fluids are heated and, if desired, cracked by a process and apparatus claimed in detail. The fluid is passed through banks of tubes within a furnace chamber where it is heated predominantly by radiant heat.

U.S.P. 2,456,787. Process and Apparatus for Heating Hydrocarbon Fluids. L. Kniel to The Lummus Company.

The invention according to this patent is related to that of U.S.P. 2,456,786. In the present case the tubes which are subjected to the greatest heat are protected from overheating by passing through them fluid which is at a relatively lower temperature than the fluid in other parts of the same tube bank.

U.S.P. 2,458,109. Conversion of Hydrocarbons. T. P. Simpson to Socony-Vacuum Oil Company, Inc.

Details of a process of converting a heavy-high-boiling hydrocarbon oil into high quality gasoline in the presence of a particle-form solid catalyst, with regeneration of the latter, are claimed.

U.S.P. 2,458,162. Method and Apparatus for Conversion of Liquid Hydrocarbons with a Moving Catalyst. W. A. Hagerbaumer to Socony-Vacuum Oil Company, Inc.

The patent relates to a method and an apparatus for the conversion of high boiling liquid hydrocarbons to lower boiling ones in the presence of a moving contact material. The particle-form contact material is introduced into a vertical conversion zone as a compact stream and then falls freely down through this zone as a shower of dispersed particles onto a compact bed thereof while a spray of the hydrocarbon charge is introduced into this particle shower. The surface level of the compact bed is maintained constant.

U.S.P. 2,458,411. Method for Contacting Gases with a Solid Contact Material. J. W. Payne to Socony-Vacuum Oil Company, Inc.

In the process of reacting a gasiform reactant with a granular inorganic contact material, e.g. in the vapor phase conversion of high boiling hydrocarbons to lower boiling ones in the presence of a particle form catalyst, the gasiform reactant is introduced into a downwardly moving compact column of the contact material at a plurality of horizontally spaced locations extending transversely from the contacting zone at a plurality of vertically spaced levels. The gasiform products are withdrawn from the column at a second plurality of correspondingly arranged locations positioned vertically intermediate to the inlet locations. The flowing column of contact material is deflected at a third plurality of locations so as to provide a plurality of substantially particle form solid-free by-pass passages for gas flow through portions of the solid material column. These passages are positioned vertically intermediate to the reactant inlet and outlet locations and horizontally outside of the direct passage for gas flow between reactant inlet and outlet locations. More uniform distribution of gas flow across the entire cross-section of the column of contact material is thereby ensured.

U.S.P. 2,458,412. Apparatus for Contacting Gases with a Solid Material. J. W. Payne to Socony-Vacuum Oil Company, Inc.

The apparatus according to this patent is designed to serve for the method of contacting gas with a solid contact material described and claimed in U.S.P. 2,458,411.

ALKYLATION

U.S.P. 2,456,435 Alkylation Process. M. P. Matuszak to Phillips Petroleum Company.

A low-boiling olefin, such as propylene, is reacted with an alkylatable cyclic organic compound, such as benzene or furan, by means of a HF catalyst in a process the details of which are claimed. Alkylated syclic compounds are obtained.

U.S.P. 2,457,564. Prefractionation of Hydrocarbon Alkylate to Eliminate Propane. L. Kniel to The Lummus Company.

A process for alkylating an isoparaffin, particularly isobutane, with a normally gaseous olefin, such as butene, for the formation of high anti-knock motor fuel, is claimed. This process includes a prefractionation of the hydrocarbon reaction mixture obtained by the alkylation to separate as overhead lower boiling unreactive hydrocarbons and a portion of the excess isoparaffin employed. The remainder of the reaction mixture is further fractionated to separate the other portion of the excess isoparaffin which is recycled together with the portion separated from the overhead.

POLYMERIZATION AND CONVERSION

U.S.P. 2,455,910. Method for Curing Ethylene Polymers. W. L. Alderson, Jr., to E. I. du Pont de Nemours and Company.

An essentially saturated ethylene polymer is blended with Na-percarbonate or a basic peroxide hydrate of Zn or Cd, and a monocarboxylic acid having at least four C atoms. The blend is heated to 100-250° C. until the polymer becomes insoluble in organic solvents.

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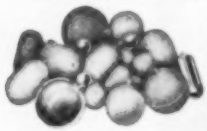

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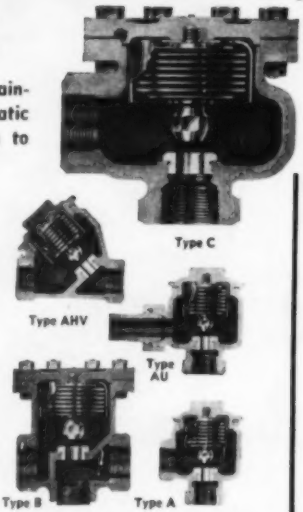

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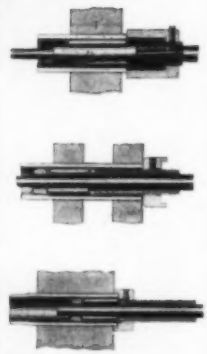

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U.S.P. 2,455,915. Catalytic Conversion of Hydrocarbons. W. H. Borcherding to The M. W. Kellogg Company.

In the catalytic conversion of hydrocarbons where powdered catalyst is introduced into the conversion zone while hydrocarbon vapors are flowed upwardly through this zone at a relatively low velocity to maintain a relatively high concentration of the powdered catalyst in this zone, this concentration is adjusted by circulating more finely divided solid inert particles through this zone. The inert particles are withdrawn overhead with the vaporous reaction products, while the catalyst particles are withdrawn from the lower portion of the zone.

U.S.P. 2,456,072. Conversion of Hydrocarbons in the Presence of a Catalyst and Calcium Oxide Together with Steam and/or Carbon Dioxide. M. M. Marisic to The Pure Oil Company.

In carrying out an endothermic catalytic reaction, such as cracking of hydrocarbon oils, in the presence of a regenerable solid catalyst, quicklime is incorporated into the catalyst. Steam and/or CO_2 is contacted during the catalytic reaction with this quicklime to produce an exothermic reaction.

U.S.P. 2,456,265. Modifying Agents for Use in Low-Temperature Polymerization Reactions. P. K. Frolich to Jasco, Inc.

An isobutylene containing olefinic material is mixed in liquid phase with a multiolefin having 4-9 C atoms, such as isoprene or butadiene. The mixture is polymerized at low temperature in the presence of Zn-stearate or another insoluble soap of a fatty acid with 6-18 C atoms by means of a Friedel-Crafts halide catalyst. A fine grained noncoalescing slurry of solid polymer is obtained due to the effect of the soap additive.

U.S.P. 2,456,306. Conversion of Hydrocarbon Oils with Finely Divided Catalyst. E. W. S. Nicholson to Standard Oil Development Company.

Continuous catalytic conversion (e.g. cracking) of hydrocarbons is effected by means of a major portion of a synthetic catalyst powder consisting of relatively large particles and a minor portion of a powder of siliceous earth (e.g. clay) of smaller sized particles. Mostly the smaller sized, less active particle powder only is entrained and lost with the gases or vapors.

U.S.P. 2,456,310. Operation of a Fluid Catalytic Conversion Unit. F. M. Orr to Standard Oil Development Company.

In a unit for the conversion of hydrocarbons by a fluidized solid catalyst to be regenerated and recycled, the circulating catalyst is maintained in fluidized state during regeneration and storage by a gasiform fluid or stream. Details of the method are claimed.

U.S.P. 2,456,338. Catalytic Polymerization of Olefinic Hydrocarbons. J. J. Stadtherr to The Pure Oil Company.

Stabilizer gases from oil cracking operations and comprising C_1 to C_5 hydrocarbons are converted to hydrocarbons boiling within the gasoline range by separating the gases into a C_4 fraction and a fraction comprising C_2, C_3 and C_5 hydrocarbons. The latter fraction is subjected to polymerization in a first zone in the presence of a solid phosphorous

acid catalyst. The C_4 fraction is heated by means of the reaction products from this polymerization and is then subjected to polymerization in a second zone in the presence of the same type of catalyst at a temperature lower than that of the first zone.

U.S.P. 2,456,348. Prevention of Siliceous Deposits in Hydrocarbon Conversion Processes. P. M. Waddill to Phillips Petroleum Company.

In a process involving the conversion of hydrocarbons, e.g. the alkylation of isobutane, in the presence of a HF-catalyst, the liquid conversion effluent is contacted with a material active in removing organically combined fluorine and containing minor proportions of silica. The SiF_4 thus formed would on later decomposition by hydrolyzation form siliceous deposits, and the patent claims a method for preventing the formation of these deposits.

U.S.P. 2,456,557. Hydrocarbon Conversion. A. Dyduszynski to Shell Development Company.

The patent relates to a process for the conversion (e.g. vapor phase polymerization) of hydrocarbons in the presence of highly active, finely divided $AlCl_3$. This catalyst is sublimed into a suitable stream of fluid material and transported in this form into the reaction zone.

U.S.P. 2,456,558. Process for the Polymerization of Styrene and Related Compounds. S. E. Glick to Monsanto Chemical Company.

Styrene, p-methyl styrene, p-ethyl styrene, chlorinated styrenes, vinyl diphenyl and vinyl naphthalene, each, are polymerized in the absence of a catalyst by first heating at 80-110° C. for 10-16 hours and then gradually raising the temperature to 120-140° C. during a period of 20-30 hours, whereupon heating at this temperature is continued for 10-16 hours and completed at 165-185° C. for 10-30 hours. The period of time required for the mass polymerization of the above-named vinyl aromatic compounds is considerably shortened by this method and products of improved flexural properties are obtained.

U.S.P. 2,456,715. Conversion of Hydrocarbons. F. W. Leffer to Universal Oil Products Company.

Details of a process for the conversion (e.g. cracking or dehydrogenation) of hydrocarbons in the presence of a suspension of solid catalyst particles are claimed.

U.S.P. 2,456,796. Hydrocarbon Coking. A. H. Schutte to The Lummus Company.

Heavy oil is injected in particle form into an upwardly moving current of heated gases and vapors while sufficient air for partial combustion is supplied. The oil particles are coked while controlling the velocity of flow to permit separation of coke particles above a predetermined desired size from smaller ones.

U.S.P. 2,456,975. Production of Motor Fuel Components. S. H. McAllister to Shell Development Company.

High yields of hydrocarbons of high power output are obtained by fractionating hydrocarbon cracking products to separate a fraction consisting of butanes, isobutylene and n-butylenes and another fraction consisting of pentanes, tert-amylenes and n-amylenes. Selective extraction with H_2SO_4 yields isobutylene from the first-named fraction and tert-amylene from the second-named fraction. On separately reacting the isobutylene extract with the residue from the tert-amylene extraction, interpolymerization of isobutylene with n-amylene is effected, and on reacting the tert-amylene extract with the residue from the isobutylene extraction, interpolymerization of tert-amylene with n-butylene is obtained. The nonylenes thus produced are hydrogenated. The acid separated from the first-named interpolymerization is fed to the tert-amylene absorption and that separated from the other interpolymerization to the isobutylene absorption.

U.S.P. 2,457,093. Apparatus for Conversion of Hydrocarbons. T. P. Simpson and L. P. Evans to Socony-Vacuum Oil Company, Inc.

The patent relates to a reactor for converting fluid reactants in the presence of a moving particle-form solid contact mass. A plurality of orifices is distributed along the length of the feed pipe for the contact mass, and these orifices at different levels may be alternately opened and closed to permit discharge of the contact mass into the reactor at any selected level.

U.S.P. 2,457,098. Apparatus for Conducting Reactions in the Presence of a Contact Mass. E. Utterback, E. L. Sinclair and J. A. Crowley, Jr., to Socony-Vacuum Oil Company, Inc.

The patent relates to the construction of a reactor or regenerating vessel to be used in hydrocarbon conversion processes, which construction allows the separation of reactant vapors or spent combustion gases, respectively, from particle-form contact material and the removal of these vapors or gases without appreciable entrainment of particles of the contact mass. Details of construction are claimed.

U.S.P. 2,457,146. Process for Producing High Boiling Polymers. H. W. Grote, R. L. Swoope and C. S. Brearley, Jr., to Universal Oil Products Company.

Propylene, or a propane-propylene fraction, containing not more than 0.03 percent of water is polymerized in the presence of a phosphoric acid catalyst compound. A fraction comprising olefins with more than ten C atoms is isolated from the resulting product. Polymers with less than 12 C atoms are recycled to the polymerization zone.

U.S.P. 2,457,232. Catalytic Conversion System. R. J. Hengstebeck to Standard Oil Company (Indiana).

A small particle size regenerated catalyst is introduced from a downwardly moving aerated column into a conversion zone underneath a regeneration zone. A gaseous stream of charging stock is passed upwardly through the conversion zone at a sufficient velocity to maintain a suspended turbulent dense catalyst phase superimposed by a light catalyst phase. Details of the hydrocarbon conversion and catalyst regeneration and of the apparatus employed are claimed.

U.S.P. 2,457,461. Catalyst Feeder. J. E. A. Graae to The Lummus Company.

A feeder device for granular material, such as hydrocarbon conversion catalyst material, is claimed. The device makes possible the transfer of this material from zone to zone in such a manner as to maintain a gas seal in the transfer without the employment of a tall sealing leg and without crushing grains of the material.

U.S.P. 2,457,701. Emulsion-Polymerization of Butadiene-1,3 Hydrocarbons. C. D. McCleary to U. S. Rubber Company.

In the preparation of synthetic rubber latex by the emulsion polymerization of butadiene-1,3 hydrocarbons and mixtures containing them, 0.05-1 part by weight of quinone per 100 parts of polymerizable material is added to the aqueous emulsion after the polymerization, while the emulsion contains unreacted polymerizable monomeric material. The viscosity of the synthetic rubber recovered from the emulsion is considerably reduced by the additive.

U.S.P. 2,458,107. Process for the Preparation of Carbon. J. H. Simons to Phillips Petroleum Company.

Non-aromatic hydrocarbons, e.g. paraffins or olefins, are oxidized in the presence of an oxidizing agent under superatmospheric pressure at a temperature of 50-200° C. in a reaction mixture containing liquid HF as an essential constituent. Carbon is recovered as a reaction product.

U.S.P. 2,458,165. Method and Apparatus for Conversion of Fluid Hydrocarbons. H. K. Holm to Socony-Vacuum Oil Company, Inc.

The details of a method and an apparatus are claimed for the conversion of fluid hydrocarbons in the presence of a particle-form contact material. This material is passed downwardly through a confined conversion zone as a compact column, and the hydrocarbon charge passes downwardly within this column. The solid particle flow is baffled in the lower portion of the column to form a continuous tortuous solid-free passage for the flow of the resulting hydrocarbon gases which are collected at a series of vertical levels.

U.S.P. 2,458,350. Method and Apparatus for Conducting Gas-Solid Contact Operations. J. A. Crowley, Jr., to Socony-Vacuum Oil Company, Inc.

The patent relates to processes wherein particle-form solid material is contacted with gaseous materials at elevated temperatures, such as the catalytic hydrogenation, dehydrogenation, polymerization, etc., of hydrocarbons. The temperature level of at least part of the solid material passing downwardly as a compact column through a contacting zone where it is contacted with a gaseous material is changed (by heat exchange) in a direction opposite to its change during contact with the gas. Details of this method, of that for regenerating the contact mass and of the apparatus employed, are claimed.

U.S.P. 2,458,432. Thiol Ester Modification of Synthetic Rubbers. W. H. Sharkey to E. I. du Pont de Nemours and Company.

A conjugated diene monomer composition which contains the diene (e.g. butadiene-1,3) in major amount is polymerized in an aqueous alkaline medium in the presence of an ester of an acyclic aliphatic monocarbothiolic acid of 1-6 C atoms having carbothiolic hydrogen replaced by the radical of a monohydric alcohol of 6-18 C atoms (e.g. 2,4,4-tri-

methyl pentyl thiolacetate). The monomer composition can contain, in addition to the diene, styrene, acrylonitrile, or the like.

U.S.P. 2,458,456. Emulsion Polymerization. I. L. Wolk to Phillips Petroleum Company.

An aqueous emulsion of a conjugated diolefin and a monomer containing an active $CH_2=C<$ group is continuously introduced into a centrifuging zone under polymerization conditions. The copolymer formed is continuously separated by the centrifugal force into a polymer-rich fraction and into unpolymerized material. The unpolymerized material is recycled.

REFINING

U.S.P. 2,457,238. Fractionation of Polymeric Ethylene. E. Hunter and R. B. Richards to Imperial Chemical Industries, Ltd.

A solid ethylene polymer with a mol. wt. of 10,000-40,000 is dissolved in ethylene gas at a pressure in excess of 500 atm. and a temperature of 50-350° C. The resulting mixture is cooled and then depressured to atmospheric pressure whereby polymers of ethylene are obtained in two solid phases.

U.S.P. 2,456,260. Process for Recovering Olefins from a Hydrocarbon Stream. A. A. Draeger to Standard Oil Development Company.

Olefins, particularly isobutylene, are removed from a predominantly C_4 hydrocarbon stream by means of H_2SO_4. Details of the process of treating the extract formed are claimed.

U.S.P. 2,456,398. Fractionation Control Apparatus. C. G. Gerhold to Universal Oil Products Company.

Details of a fractionating column are claimed which is provided with a variable volume closed chamber disposed at a selected control point within the column. The apparatus is particularly intended for use in the oil refining industry to separate fractions with relatively close boiling ranges.

U.S.P. 2,456,561. Azeotropic Separation of Xylene Isomers. G. R. Lake and J. M. McDowell to Union Oil Company of California.

A xylene fraction containing non-aromatic hydrocarbons of the same boiling range as the xylene fraction is distilled in the presence of methyl ether of the ethylene glycol acetate to vaporize the non-aromatic hydrocarbons present together with the additive. The xylenes left in the residue are subsequently distilled in the presence of another amount of the same additive to vaporize at least one isomer xylene (the m- and/or p-xylene) with the additive. The method can also be employed for the decomposition of a fraction composed of o-, p-, and/or m-xylene only.

U.S.P. 2,456,569. Motor Fuel. A. I. Smith to Union Oil Company of California.

The Diesel fuel according to this patent contains an addition of 0.01-2 percent of an alkyl mono-amine or a fatty amide. The additive is oil soluble and surface active, has a mol. wt. greater than 150 and contains at least one C chain of more than 8 C atoms. Gum precipitation is prevented by the additive.

U.S.P. 2,456,722. Selective Copper Solvent for Diolefin Extraction. C. E. Morrell and M. W. Swaney to Standard Oil Development Company.

A C_5 diolefin is separated from a C_5 mono-olefin, e.g. isoprene from pentene-1, by selectively absorbing the diolefin in an alkyl amine cuprous salt-complex solution, e.g. a mono-methyl-amino-cuprous acetate complex, with a pH value above ten. The ahimno-olefin which remains undissolved is separated, and the diolefin is desorbed from the solution.

U.S.P. 2,456,723. Selective Copper Solvent for Diolefin Extraction. L. K. Beach to Standard Oil Development Company.

The process of this patent is closely related to that of U.S.P. 2,456,722. An alkyl amine cuprous acetate complex is here employed for the separation of an unsaturated hydrocarbon from a mixture containing also a more saturated hydrocarbon.

U.S.P. 2,457,361. Styrene Distillation. T. A. Gadwa to The Lummus Company.

A styrene-containing mixture derived from the dehydrogenation of ethyl benzene to styrene and including benzene, toluene, ethyl benzene and higher boiling materials is subjected to an initial distillation under a pressure of 160 mm. Hg, whereby toluene, lower boiling materials and about 20 percent of the ethyl benzene are removed as overhead. Styrene is removed from the remaining bottoms by further distillation under a substantial vacuum.

U.S.P. 2,457,457. Methods for Treating Bituminous Shales. J. L. M. Fréjacques to Compagnie de Produits Chimiques et Electrometallurgiques Alais, Froges et Calmargue.

Bituminous schists are initially distilled in the presence of a recycle oil fraction obtained from a prior fractionation. The resulting distillate oil is fractionally distilled. The resulting lighter fraction is subjected to polymerization in the presence of a metal halide catalyst. A lubricating oil and a recycle oil are obtained by fractionation of the polymerization product.

U.S.P. 2,457,634. Breaking Emulsions. D. C. Bond and M. Savoy to The Pure Oil Company.

Water-in-oil emulsions, e.g., such of mineral oils, are broken by mixing them with a small amount of an agent prepared by forming a non-resinous reaction product of a mineral acid and a viscous oil. This viscous oil is the product of the reaction induced at about ambient temperature and in the presence of a small amount of water between equimolar amounts of a hydroxy substituted sec. aliphatic amine, an alkyl substituted monohydroxy benzene and an aldehyde.

U.S.P. 2,457,735. Breaking Water-in-Oil Emulsions. M. Savoy to The Pure Oil Company.

A water-in-oil emulsion is broken by mixing therewith a small amount of an ammonium salt or an alkali metal salt of sulfonated substantially-pure pinene or limonene.

U.S.P. 2,458,049. Treatment of Hydrocarbons Containing Neutral Organic Sulfate. H. S. Bloch and G. L. Hervert to Universal Oil Products Company.

Hydrocarbons containing neutral organic sulfate (e.g. as a contaminant from alkylation or polymerization treatments of hydrocarbons with H_2SO_4) are heated in the presence of a solid, anhydrous, basic substance, such as an alkali or alkaline earth metal carbonate. Removal of neutral organic sulfates from the hydrocarbons is considerably facilitated by this treatment.

U.S.P. 2,458,067. Process for Separating Olefins from Paraffins. B. S. Friedman and R. F. Stedman to Universal Oil Products Company.

A mixture containing olefinic and paraffinic hydrocarbons is contacted with a solution of a silver salt, such as $AgNO_3$, in a water-soluble aliphatic nitrile, e.g. aceto- or succino-nitrile. The olefins are dissolved and extracted by this solution.

HEAVY OILS AND WAXES

U.S.P. 2,456,283. Textile Wax Compositions. G. D. Jefferson to Atlas Powder Company.

The composition according to this patent consists of 40-70 percent hydrocarbon wax, 6-30 percent polyethylene glycol monostearate produced in a particular manner and 10-40 percent stearic acid. This composition is particularly useful as a textile sizing material.

U.S.P. 2,456,336. Agent and Mineral Oil Lubricant Compositions Containing the Same. H. G. Smith and T. L. Cantrell to Gulf Oil Corporation.

An essentially paraffinic base lubricating oil is heated with P_2S_5 in the presence of a surface active silica-containing catalyst at a temperature of from 300° F. to below the minimum cracking temperature of the oil. The P and S containing reaction product is employed as an additive for mineral oil lubricants, turbine oils and the like to import antioxidant and corrosion-inhibiting properties to them.

U.S.P. 2,456,587. Soluble Oil Composition. R. M. Koppenoefer to Socony-Vacuum Oil Company, Inc.

An emulsifiable composition, which is stable in the presence of dissolved aluminum or other acidic electrolytes and useful in the treatment of leather, is obtained from a mineral oil by additions of rosin acid, a polyosyalkylene derivative of a higher fatty acid ester of a hexitol anhydride, a lower fatty acid, and one of certain glyoxalidine compounds.

U.S.P. 2,456,692. Lubricating Oil Composition. A. Farkas and A. F. Stribley, Jr., to Union Oil Company of California.

The details of a process are claimed for producing a lubricating oil addition agent by partial oxidation of a non-aromatic cyclic hydrocarbon and treatment of the product obtained with P_2S_5 or P_2O_5. The phosphate esters thus formed are transformed into salts of a polvalent metal.

U.S.P. 2,457,518. Waterproofing Plastic Compositions. J. A. Bell to Shell Development Company.

A waterproof plastic insulating com-

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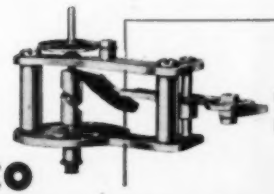

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position consists of 10-35 percent of dehydrated asbestos fiber with low moisture content, 25-55 percent of a mineral lubricating oil, and 10-40 percent of a water-insoluble soap of a mixture of distilled fatty acids with 16-18 C atoms and wool grease stearine.

U.S.P. 2,457,582. Grease Composition. P. R. McCarthy to Gulf Research and Development Company.

The grease composition comprises 55-80 weight percent of a refined mineral oil of a viscosity of 500-2000 S.U.V. at 100° F., 10-20 percent asphalt, and 10-25 percent of a mixture of alkali-metal and zinc fatty acid soaps.

U.S.P. 2,457,586. Grease Composition. J. F. McGrogan to The Atlantic Refining Company.

The grease consists of mineral lubricating oil, calcium soaps of fatty acids and a small amount of a lead salt of an aliphatic monocarboxylic acid with not more than 8 C atoms to increase the dropping point of the grease.

U.S.P. 2,458,034. Mineral Castor Oil. R. A. Swenson and A. W. Weitkamp to Standard Oil Company (Indiana).

A major proportion of a hydrocarbon oil is compounded with a 0.5-15 percent of an aluminum soap, 0.05-5 percent of a polyhydric alcohol and 0.005-2 percent of a metal soap of a preferentially oil-soluble sulfonic acid. This so-called mineral castor oil is useful for lubricating bearings, differentials and the like and is characterized by its stability.

U.S.P. 2,458,425. Oil Compositions. A. G. Rocchini to Gulf Research and Development Company.

The oil composition according to this patent consists of a major proportion of a mineral oil, particularly an oil of lubricating viscosity, and a minor proportion of an oil-soluble polyvalent metal salt of an alkenyl-succinic acid monoamide in which the alkenyl group contains 5-18 C atoms. The additive improves the detergent, anti-oxidant and anti-corrosion characteristics of the mineral oil.

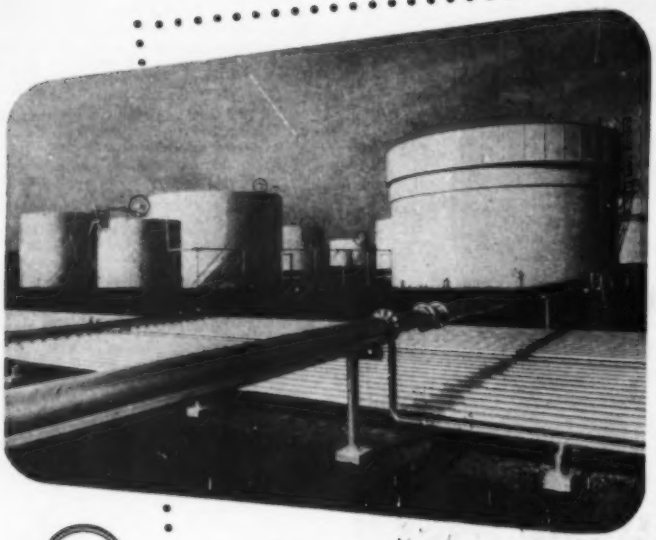
PETROCHEMICALS

U.S.P. 2,455,995. Production of Nitriles from Certain Olefins and HCN. C. R. Harris and W. W. DeAtley to E. I. du Pont de Nemours and Company.

Hydrocarbons with not more than ten C atoms and an aliphatic chain containing one double bond linking a tertiary, or secondary C atom to another C atom are reacted with HCN in the vapor phase in the presence of activated alumina, silica, titania or Mg-silicate, or mixtures thereof at 250-500° C. Nitriles are produced.

U.S.P. 2,456,119. Production of Surface Active Agents. B. S. Friedman and G. L. Hervert to Universal Oil Products Company.

Surface active agents, particularly detergents, are produced by treating a naphtha fraction containing olefins which boil between 160° and 240° C. with an agent capable of removing therefrom condensed-ring aromatic hydrocarbons and nitrogen- and sulfur-containing organic compounds. The thus treated naphtha fraction is used for alkylating a benzenoid hydrocarbon containing at least 2 replaceable nuclear hydrogen



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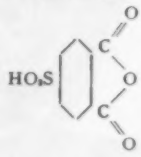
atoms. The alkyl aromatic hydrocarbon fraction with an alkyl group of 10-16 C atoms thus obtained is sulfonated and transformed into a salt.

U.S.P. 2,456,085. Cation-Exchange Resins Prepared by Condensing Sulfophthalic Anhydride and Xylene. S. P. Rowland to Rohm and Haas Company.

An insoluble, infusible, porous resin with cation-exchange properties is produced by condensing 2 mols of xylene with 1 mol of the sulfophthalic anhydride



The gel-like condensation product is dried and converted into the insoluble acidic resin by heating.

U.S.P. 2,456,173. Photochlorination of Acetylene. O. W. Cass to E. I. du Pont de Nemours and Company.

Acetylene and chlorine are reacted in a liquid miture of tetrachlorethane, pentachlorethane, and beta-trichlorethane under the influence of light from ultraviolet through the visible range at a temperature of 0-80° C. in the absence of free oxygen and catalysts. In addition to acetylene tetrachloride, substantial amounts of pentachlorethane and beta-trichlorethane are formed.

U.S.P. 2,456,350. Preparation and Isolation of Ethylene Chlorohydrin. C. Weizmann to Ketarome Ltd., London.

In the treatment of ethylene with hypochlorous acid, the ethylene chlorohydrin formed is isolated by contacting the reaction product with a liquid neutral organic solvent which contains a carbonyl group, such as an aldehyde, a C_4 to C_8 ketone, or an acetic acid ester.

U.S.P. 2,456,354. Copolymers of Iso-Olefins with Thiophene Sulfones and Process for Making Same. D. W. Young to Standard Oil Development Company.

A major proportion of isobutylene or another iso-olefin is copolymerized in mixture with a minor proportion of a dialkyl thiophene-1,1-dioxide with one to ten C atoms per alkyl group at a temperature of 0° to —164° C. in the presence of a Friedel-Crafts catalyst.

U.S.P. 2,456,597. Production of Phenol by Catalytic Oxidation of Benzene. C. H. Schlesman, W. I. Denton and R. B. Bishop to Socony-Vacuum Oil Company, Inc.

Details of a continuous catalytic vapor phase process for the production of phenol by oxidation of benzene are claimed. The solid porous adsorbent metal oxide catalyst is moved countercurrently to a mixture of benzene and air to be treated. V_2O_5 is the preferred catalyst material.

U.S.P. 2,457,660. N-Tertiary Alkyl Amides and Method for Preparing Same. W. F. Gresham and W. E. Grigsby to E. I. du Pont de Nemours and Company.

A nitrile is reacted with a tertiary olefin in an aqueous medium containing 1-20 percent (based upon the weight of

the water present) of an acid-reacting catalyst. An organic acid amide having a tertiary C atom attached to the amide nitrogen is separated from the reaction mixture.

U.S.P. 2,456,382. Copolymer of Cyclohexyl Alpha Chloroacrylate and Butadiene-1,3. A. M. Clifford to Wingfoot Corporation.

Masses useful as synthetic rubbers are formed by the copolymerization of butadiene-1,3 and cyclohexyl alpha chloroacrylate (for example in emulsion).

U.S.P. 2,457,696. Synthesis of Unsaturated Ketones. G. E. Lukes and R. C. Swann to The Pure Oil Company.

An open-chain olefinic hydrocarbon with at least three C atoms is contacted with a fatty acid anhydride in the presence of an aryl sulfonic acid, a sulfofatty acid or a halo-sulfonic fatty acid as a catalyst. Unsaturated ketones are obtained, e.g. methyl diisobutylene ketone from crude diisobutylene and acetic anhydride.

U.S.P. 2,457,825. Acylating Thiophene. A. I. Kosak and H. D. Hartough to Socony-Vacuum Oil Company, Inc.

Thiophene is reacted with an acyl halide or the anhydride of a carboxylic acid in the presence of iodine as a catalyst. Acylated thiophene is obtained.

HYDROGENATION, DEHYDROGENATION, AROMATIZATION

U.S.P. 2,456,672. Conversion of Hydrocarbons. H. S. Bloch and R. E. Schaad to Universal Oil Products Company.

A normal paraffin with at least four C atoms is subjected simultaneously to dehydrogenation and isomerization in the presence of a physical mixture of suitable catalysts. A mixture of iso- and n-olefins together with unconverted n-paraffin is formed. Iso-paraffin is then added and is alkylated with the olefins. Unconverted n-paraffin and iso-paraffin are separated from the effluent by fractionation and recycled to the charge stock and the alkylation step, respectively.

U.S.P. 2,458,082. Production of Diolefins. M. O. Kilpatrick to Phillips Petroleum Company.

A mixture of butenes and five to ten percent by vol. of C_5 hydrocarbons more saturated than diolefins, such as pentenes, is contacted at a temperature of 1000-1300° F. with a dehydrogenation catalyst in the presence of 8-15 vols. of steam per vol. of hydrocarbon mixture. A mixture of butadiene and isoprene is obtained by the simultaneous dehydrogenation of the C_4 and C_5 hydrocarbons.

DESULFURIZATION

U.S.P. 2,457,975. Removing Mercaptans. J. A. Bolt to Standard Oil Company (Indiana).

Sour naphtha is contacted with a caustic alkali solution containing phenols as a solutizer for mercaptans. Mercaptans and phenols are extracted by the caustic solution. The caustic solution separated from the naphtha is regenerated and recycled. The phenol concentration of the caustic solution is con-

FIG. 2228 SCREW ENDS
FIG. 2229 FLANGE ENDS
Double disc, rising stem

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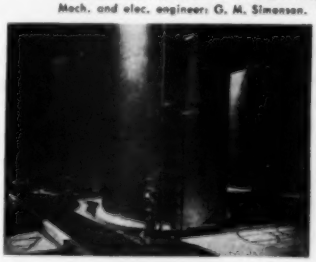

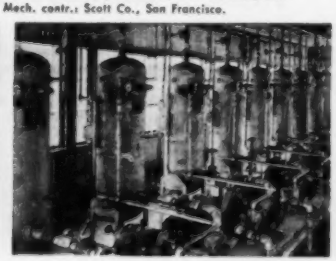

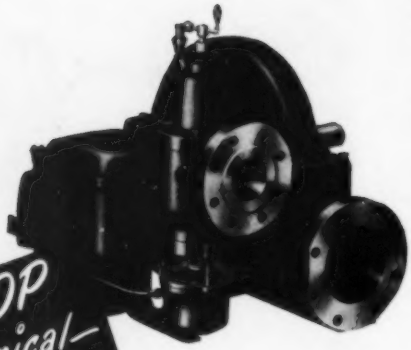

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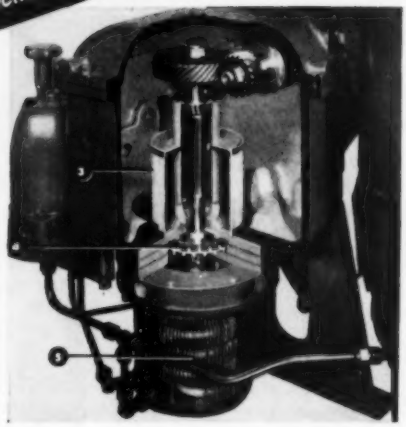

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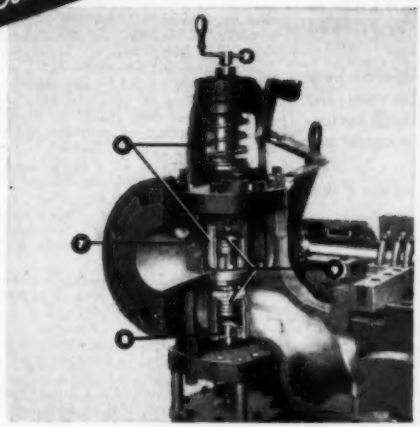

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8 MAINTENANCE REDUCED by valve stem sealing bushings —no soft packings required.
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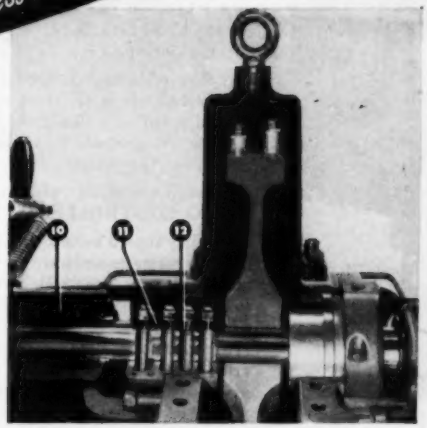

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11 SHAFT EROSION PREVENTED by Monel spray under packings.
12 STEAM LEAKAGE sealed off by heavy double-seal carbon packings.

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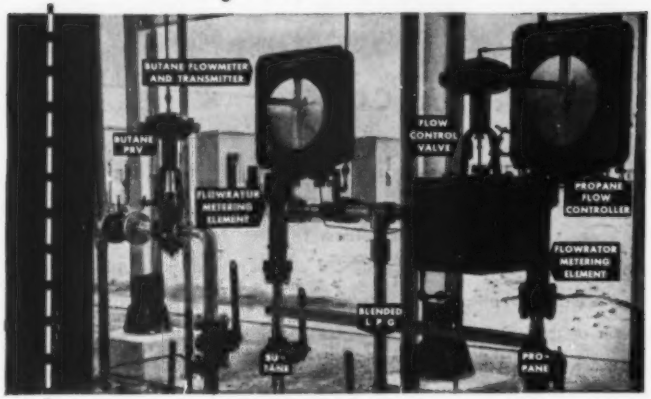

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The flow of butane is accurately measured by a FLOWRATOR meter-transmitter. This resets the control point on a similar FLOWRATOR instrument which controls the amount of propane put into the LPG mixture.

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1) They record butane and propane flows; valuable operating records are produced without additional flowmeters. 2) Their flow scales are uniformly spaced; peak accuracy is assured over the entire range of flow measurement. 3) They are free of electrical connections; safe in hazardous areas. 4) They require no "meter runs"; installation cost are low. 5) There is just one moving part, free of packing glands; maintenance costs are negligible.

For detailed engineering information write for Bulletin 53.

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trolled by contacting a certain portion of it with a stream of naphtha of different specific gravity than the treated one to transfer part of the phenols contained in one or the other of these naphthas to that poorer in phenols. Sour light naphtha substantially free of phenols as well as sour heavy naphtha containing phenols can be treated by this method.

CATALYST PREPARATION, ACTIVATION, AND REGENERATION

U.S.P. 2,456,148. Stripping of Spent Catalyst in Hydrocarbon Conversion Processes. D. Read, Jr., to Universal Oil Products Company.

A naphtha fraction obtained from the products of hydrocarbon conversion in the presence of a solid catalyst is employed for displacing high boiling hydrocarbons from the contaminated catalyst. The naphtha held by the catalyst is then removed by combustion gases before regenerating the catalyst. Details of this method are claimed.

U.S.P. 2,456,268. Catalyst Preparation. F. C. Gibbs, Jr., B. M. Baird and R. J. Brosamer to Phillips Petroleum Company.

A solution of Na_2SiO_3 is added to an aqueous acid solution. The hydrous gel formed is washed, partially dried and washed again to reduce acidity. The gel is then treated with an aqueous acid activating solution consisting of aluminum sulfate and an effective amount of an alkali metal-base or a salt of such a base with a weak acid to maintain the acidity of the activating solution at a pH above two during the treatment. The activated gel is washed and dried.

U.S.P. 2,456,326. Preparation of Supported Aluminum Chloride Catalysts. W. H. Rupp and C. T. Harding to Standard Oil Development Company.

A catalyst useful in the isomerization of n-paraffins is obtained from bauxite which is first dehydrated by passing anhydrous butane or pentane through it at a temperature of 250-350° F. until the water content is 1.5-3 percent. $AlCl_3$ is treated with anhydrous butane or pentane under similar temperature conditions and the resultant vapor admixture is then passed through the dehydrated bauxite to impregnate it with $AlCl_3$.

U.S.P. 2,456,367. Calcium-Nickel Phosphate Catalyst and Preparation Thereof. E. C. Britton and A. J. Dietzler to The Dow Chemical Company.

A dehydrogenation catalyst for olefins, or the like, is formed from certain specific proportions of a non-alkaline aqueous solution of a Ca-compound and a Ni-compound, and an ortho-phosphate by precipitating from this solution a corresponding normal metal phosphate.

U.S.P. 2,456,576. Process of Stabilizing Treatment of Inorganic Oxide Gels Against Wetting. E. A. Bodkin and J. W. Payne to Socony-Vacuum Oil Company, Inc.

Dry inorganic oxide gels to be used as catalysts or adsorbents in the treatment of hydrocarbons, e.g. silica-alumina gels, are stabilized against disruption upon wetting with an aqueous liquid. The gel is saturated at ordinary temperature with a water-soluble, non-aqueous, nor-

mally gaseous material (such as CO_2, NH_3 or Cl_2) which is chemically inert toward the aqueous liquid. This saturation of the gel is maintained until it is contacted with the aqueous liquid.

U.S.P. 2,456,368. Calcium Nickel Phosphate-Chromium Oxide Catalyst. E. C. Britton and A. J. Dietzler to The Dow Chemical Company.

The calcium nickel phosphate material obtained by the process described in U.S.P. 2,456,367 is intimately mixed with a lesser amount of chromium oxide. The resulting mixture is effective as a catalyst for the dehydrogenation of aliphatic mono-olefins with at least four C atoms in the unsaturated chain.

U.S.P. 2,456,525. Supported Sodium Catalyst and Preparation Thereof. G. A. Hille to Houdry Process Corporation.

An inert non-porous carrier of extensive surface area, such as glass-wool, is treated with a solution of sodium in liquid ammonia. The ammonia is then evaporated while preventing access of air and moisture to the treated material. An active Na-catalyst useful in hydrocarbon polymerizations is obtained.

U.S.P. 2,456,577-8. Process of Stabilizing Inorganic Oxide Gels Against Wetting. E. A. Rodkin and J. W. Payne to Socony-Vacuum Oil Company, Inc.

The purpose of the methods described in these patents is the same as in U.S.P. 2,456,576. According to U.S.P. 2,456,577 the gel is saturated with a water-miscible, substantially water-free organic liquid in which the gas contained in the pores of the gel is soluble to a greater extent than in water. Examples of such saturating liquids are water-miscible alcohols and ketones.

According to U.S.P. 2,456,578 a water-miscible liquid is employed which has a viscosity of at least 20 centipoises as the temperature of treatment. Examples of such liquids are: suitable solutions of sugar, dextrin, and silicate.

U.S.P. 2,456,633. Catalyst Preparation. V. Haensel to Universal Oil Products Company.

An inorganic oxide carrier, such as silica, is treated with a solution of a normally solid aromatic hydrocarbon, such as diphenyl. A metal from group VIII of the periodic table, e.g. Pt or Pd, is subsequently composited therewith. A catalyst useful in the hydrogenation of unsaturated compounds is obtained. It effects hydrogenation at lower temperatures and in a shorter time than a corresponding catalyst prepared without the pre-treatment of the carrier.

U.S.P. 2,456,707. Process for Stripping Spent Fluid Catalysts. P. C. Keith to Hydrocarbon Research, Inc.

Spent fluidized catalyst from a hydrocarbon conversion process is stripped from hydrocarbons through fluidization with oxygen of not less than 95 percent purity.

U.S.P. 2,456,721. Catalyst Manufacture. T. H. Milliken, Jr., and I. H. Welinsky to Houdry Process Corporation.

The preparation of a zirconia-silica catalyst of improved characteristics in the cracking and conversion of hydrocarbons is described. An acid hydrogel of silica and zirconia is prepared at a pH of 2.5 to about 6, e.g. from an alkali metal silicate and a soluble zirconium salt in the presence of a buffer, such as

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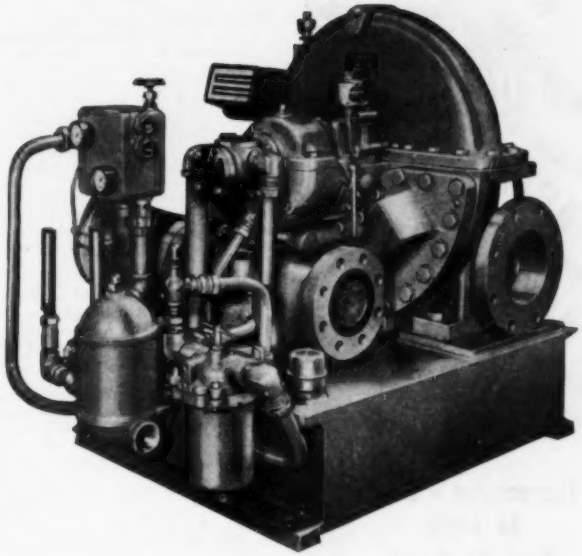

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Pictured above is such a machine designed to deliver 400 HP at 7400 RPM. This machine is arranged for speed adjustment by means of hand control or by automatic control. The turbine is also equipped with a vibrating type speed indicator and a remote control tripout device. Note that the construction provides an oil tank of generous oil capacity. The combined base and tank arrangement may be extended for mounting the driven machine if desired.

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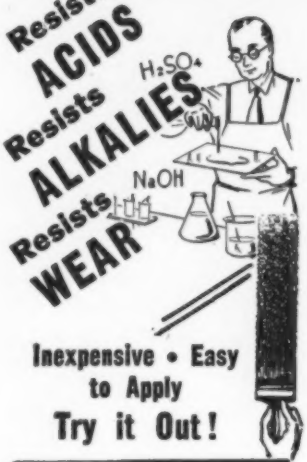

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an ammonium salt. The gel is subjected to accelerated aging under controlled conditions of time, temperature, and humidity, the moisture content of the aging atmosphere being at least 68 percent relative humidity. The hydrogel is then rapidly dried until it is converted to dried gel, which can be calcined at temperatures above 800° F.

U.S.P. 2,457,255. Stripping of Spent Catalyst in a Hydrocarbon Conversion Process. P. F. McElherne to Standard Oil Company (Indiana).

Spent hydrocarbon conversion catalyst is first stripped for removal of vaporizable hydrocarbons and then regenerated by combustion of carbonaceous residues. The stripping is effected solely by heating the base of the stripping zone to a temperature substantially higher than that in the conversion zone. The spent catalyst is passed downwardly through the stripping zone and is thereby subjected to increasing temperatures. Further details are also claimed.

U.S.P. 2,457,556. Regeneration of Synthetic Metal Silicate Adsorbents by Oxidation. H. Heinemann and K. A. Krieger to Attapulgus Clay Company.

Spent synthetic metal silicate adsorbent, as employed for example in the refining or conversion of hydrocarbons, is purged with steam to remove at least a portion of the adsorbed carbonaceous materials. Moisture from this steaming operation is removed from the silicate at a temperature of less than 700° F. before it is heated to a higher temperature and treated in a dry air current for a time sufficient to burn off carbonaceous materials.

U.S.P. 2,457,635. Method of Regenerating Aqueous Alkali Solution Used to Extract Weakly Acidic Sulfur Compounds from Hydrocarbon Fluids. D. C. Bond and M. Savoy to The Pure Oil Company.

Weakly acidic sulfur compounds occurring in petroleum hydrocarbons are contacted with free-oxygen containing gas in the presence of an aqueous alkali solution containing 0.1-3 percent by weight of an added phenolic substance less effective than hydroquinone as an oxidation catalyst, and of 0.0001-1 percent of a Cu, Ni, Co or Fe salt soluble in the alkali solution. The process is useful in the regeneration of alkali solutions spent in the extraction of sulfur compounds from hydrocarbons.

U.S.P. 2,457,719. Preparation of Extruded Iron Oxide Catalysts. P. R. Pine and E. C. Ray to The Harshaw Chemical Company.

Iron oxide catalysts useful in hydrogenation, dehydrogenation, and similar processes are obtained from a paste of certain proportions of ferrous carbonate, a compound of a metal of atomic number 22-30 (excluding iron), and a compound of an alkali metal, both capable of yielding the oxide on calcination. The paste, which shall contain a suitable amount of water, is extruded to form catalytic bodies of the desired size and shape, heated to remove the water, and then calcined.

U.S.P. 2,457,837. Multistage Regeneration of a Moving Bed Catalyst. T. P. Simpson and C. V. Hornberg to Socony-Vacuum Oil Company, Inc.

In the regeneration of a moving, substantially compact column of particle-

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form contact material contaminated by carbonaceous deposit, the contact material flows as a compact, vertical, continuous column downwardly through a series of regeneration zones. The contact material is supplied to the uppermost zone at a temperature substantially below that desired for the regeneration. Regenerating gas is independently introduced to each zone and independently withdrawn therefrom. The temperature of the contact material is quickly raised to burning temperature in the uppermost zone and it is maintained in each zone at such temperature but below a temperature which would cause damage to the contact material. A spread of the burning flame fronts is effected in the intermediate zones by recycling a separately controlled amount of gaseous regeneration products to each of these zones.

U.S.P. 2,457,970. Process for Producing Microspherical Silica Gels. J. C. Bailie to Standard Oil Company (Indiana).

An alkali metal silicate solution containing 2 to 10 percent SiO_2 is contacted with an ion exchange resin which exchanges the alkali metal ions. The resulting solution is dispersed in a stream of drying gas and is thus formed into microspherical droplets which are subsequently gelled and dried while in suspension in the gas. The size of the droplets is controlled by adjustment of the viscosity of the silica solution before its dispersion. An alkali metal-free product is obtained.

U.S.P. 2,457,971. Silica Sol. V. Voorhees to Standard Oil Company (Indiana).

The concentration of an alkali metal silicate solution is adjusted to a SiO_2 content of 10-30 percent. This solution is then passed through a porous granulated mass of an ammonium ion exchanger ,e.g. an ammonium ion-exchange resin. An alkali metal-free silica sol is obtained.

U.S.P. 2,458,044. Method of Recovering Hydrogen Fluoride from an Azeotropic Mixture by Crystallization. C. Alexander to Phillips Petroleum Company.

HF is recovered from its azeotropic mixture with water (as obtained for example in the alkylation of low-boiling isoparaffins with olefins in the presence of a HF catalyst) by cooling the mixture to form crystals (e.g. to a temperature of —55 to —100° C.). The recovered crystals are melted, and the resulting liquid is fractionally distilled. HF is recovered as overhead product from this distillation.

U.S.P. 2,458,358. Process of Regenerating a Moving Bed of Solid Catalyst. L. P. Evans to Socony-Vacuum Oil Company, Inc.

This patent, just as U.S. patents 2,458,356-7, relates to details of a process for burning carbonaceous deposits from particle-form contact materials and it makes use for this purpose of a principle of contacting the solids and regenerating gases similar in part to that described in U.S.P. 2,458,165.

U.S.P. 2,458,359. Process of Multiple-Zone Regeneration of a Moving Bed Catalyst. L. P. Evans to Socony-Vacuum Oil Company, Inc.

The details of a method for regenerating particle-form solid catalysts and the like by a particular manner of conduct-

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ing and contacting the solids and the regenerating gases are claimed.

U.S.P. 2,458,356. Method and Apparatus for Burning Contaminants from a Moving Bed Contact Mass. L. P. Evans to Socony-Vacuum Oil Company, Inc.

The details of a process and an apparatus for burning contaminant deposits from a particle form contact material are claimed. The spent contact mass and a regenerating gas are flowed through a combustion zone in a plurality of separate, parallel alternate solid and gas streams in free contact with one another, and the contact material is gravitating downwardly in a zigzag path.

U.S.P. 2,458,357. Method and Apparatus for Conducting Reactions in the Presence of a Contact Mass. L. P. Evans to Socony-Vacuum Oil Company, Inc.

The object of this patent is similar to that of U.S.P. 2,458,356 and it makes use of the same principle.

U.S.P. 2,458,433. Method for Contact Material Regeneration. T. P. Simpson to Socony-Vacuum Oil Company, Inc.

A spent solid particle form contact material is regenerated by passing it downwardly through a plurality of burning zones interrupted by heat exchange zones where the solid material is heated by the released combustion heat to a temperature suitable for rapid contaminant combustion but below a temperature which would damage the contact material.

U.S.P. 2,458,434. Method and Apparatus for Regenerating Moving Bed Particle Form Contacts Mass Materials. T. P. Simpson to Socony-Vacuum Oil Company, Inc.

Contaminated particle form solid contact material is regenerated while passing downwardly at a controlled rate through a vertical series of burning zones. An oxygen-containing gas is introduced into the column of contact material at a centrally located level in each of these zones. A portion of this gas is passed upwardly and the remaining portion flows downwardly within the column. Gaseous combustion products are withdrawn separately adjacent to either end of each zone. Heat exchange is effected between most of the burning zones in a manner similar to that described in U.S.P. 2,458,433.

U.S.P. 2,458,435. Method and Apparatus for Regenerating a Moving Bed Contact Material. T. P. Simpson to Socony-Vacuum Oil Company, Inc.

The method for regenerating particle form contact material claimed in this patent is similar to that described in U.S. patents 2,458,433-4. In the present case the burning of the contaminants is effected alternatingly in combustion zones without cooling and in such zones where indirect heat transfer with a cooling fluid takes place simultaneously with the burning of the contaminants.

U.S.P. 2,458,487. Method and Apparatus for Conducting the Regeneration of a Moving Bed Catalyst. J. A. Crowley to Socony-Vacuum Oil Company, Inc.

The method, details of which are claimed in this patent, is similar to those described in U.S. patents 2,458,433-5 for the regeneration of contaminated particle form solid contact materials.

NEW EQUIPMENT and Manufacturers' Literature

For copies of manufacturers' literature or more information on products described on these pages write to the address shown, using the number shown for each item.

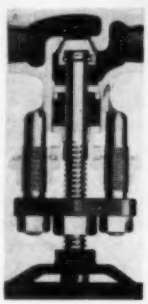
"Wetter Water" Movie

"Fire Fighting with Wetter Water," a new 20-minute 16 mm. sound movie in color by Carbide and Carbon Chemicals Corporation, is available for showings to municipal, volunteer and industrial firemen or groups interested in fire-fighting and fire prevention. The movie illustrates how water made wetter by the Corporation's new product, "Unox" fire-fighting penetrant, knocks out fires three to four times faster than plain water.

For further information write Carbide and Carbon Chemicals Corporation, Room 328, 30 East 42nd Street, New York 17, referring to PETROLEUM REFINER item **94.**

Valves

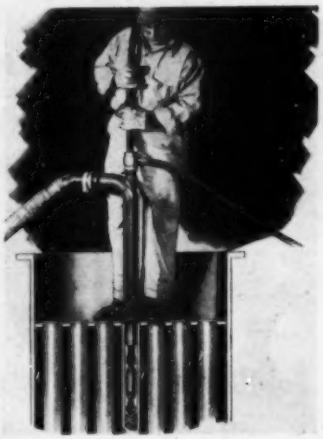
Manning, Maxwell and Moore, Inc., have announced a "major and exclusive" improvement in the seat design of its line of Hancock Series 60 globe and angle weld-valves two inches and smaller. These valves will be supplied, as a standard feature, with integral stellite seats. By providing seating surfaces of super-hard stellite, integral with the valve body, "the need for seat replacement is completely eliminated," and "leaks between the body and seat, unavoidable with screwed-in, spun-in or rolled-in seat construction, are no longer possible."



For further information write Manning, Maxwell and Moore, Inc., Watertown 72, Mass., referring to PETROLEUM REFINER item **93.**

Tubular Catalyst Cleaner

A new development of removing the corrosive spent catalyst material from tubular reactors is described in Elliott Company's quarterly publication, "Powerfax." The Lagonda tube cleaner unit "makes catalyst cleaning a simple, one-man job, accomplished conveniently from the top of the reactor." The equipment weighs only 30 pounds and utilizes a standard air-driven tube cleaner motor which has enough clearance in the tube to permit loosened catalyst to be blown by exhaust air from the motor to the top of the tube where it is discharged through an elbow. A pneumatic dust seal at the top prevents dust leakage.



The deflector elbow is fitted with an adapter which fits the end of the tubes. A sponge rubber gasket seals the tube end. The tube cleaner motor is equipped with a special fishtail bit. Tubes frequently become metal bright by the sand-blasting effect of the broken up catalyst and "there is no possibility of damage to the tubes."

For further information write Elliott Company, Jeannette, Pa., referring to PETROLEUM REFINER item **95.**

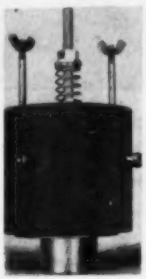
Microscope Illuminator

Designed for routine and advanced laboratory work by American Optical Company, the new microscope illuminator supplies both Kohler and parallel illumination for bright field and phase microscopy, photomicrography, mincroprojection and dark field illumination. Ventilating fins on the die-cast aluminum body, coupled with natural draft ventilation, assure cool operation. A screw-type tilting adjustment, operating in a threaded nut, is placed low and to the rear of the base for handling coolness. Available with or without an iris diaphragm which has both knurled ring and knob adjustments, the lamp has a single filter holder for either ground or blue glasses and a multiple filter holder attachment which accommodates up to four rectangular filters simultaneously.

For further information write American Optical Company, Southbridge, Mass., referring to PETROLEUM REFINER item **96.**

Air Cells

Two new Tate-Emery air cells having load ranges of 0-1.2 to 0-6 pounds and 0-2 to 0-10 pounds in tension and compression are announced by The Baldwin Locomotive Works. These load-weighing devices were designed for use on testing machines of any type or capacity to give high precision measurement of small loads such as in testing plastics, textiles, cord, paper, and other material. They can also be used independently for such purposes as weighing chemicals, or controlling chemical processes. An air jet and baffle within the cell controls the action of a pneumatic force balance system, so that air pressure automatically balances the load. Total movement of the load-sensitive member is less than 0.0005 inch. Accuracy of load measurement is "within ¾ percent of reading or 0.15 percent of capacity, whichever is greater," when Bourbon gauge type indicators are used. This becomes ½ percent of reading or 0.1 percent of capacity, whichever is greater, for the Tate-Emery load indicator.



For further information write The Baldwin Locomotive Works, Philadelphia 42, referring to PETROLEUM REFINER item **97.**

Walkways, Loading Racks

Safwalk walkways, platforms, and loading racks, manufactured by Black, Sivalls and Bryson, Inc., are constructed of all-steel pre-cut and pre-punched panels made in 4-, 5-, 6- and 8-foot lengths. Angles are supplied in stock lengths of 20 feet. Any desired length may be assembled by using combina-

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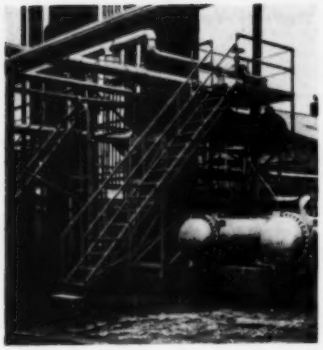
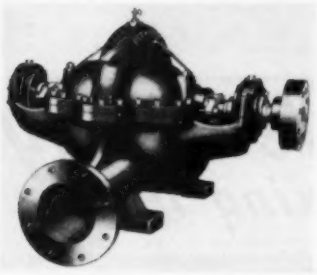


tions of these lengths. The various structural parts are bolted together with ⅜ or ½-inch galvanized tank bolts. Features of the panels are "simplicity of erection and shipment, strongness and safety, as well as having high salvage value and being fireproof." Construction details and photographs of the completed products are included for typical applications.

For a copy of Part 1, Section 6 of Catalog 54 write Black, Sivalls and Bryson, Inc., 720 Delaware, Kansas City 6, Mo., referring to PETROLEUM REFINER item **98.**

Horizontal Centrifugal Pumps



The horizontal centrifugal pumps of Peerless Pump Division of Food Machinery and Chemical Corporation are for general purpose pumping of water and alkaline fluids up to 300° F. Type A is a single-stage, double-suction, split-case design, has a capacity of 60,000 gpm. against heads up to 300 feet and is available in sizes from 1¼ through 48 inches. All types of drives may be employed. The upper half of the case has water seal pipe to the stuffing boxes, air vents and lifting eyes. Drain plugs are provided in the lower half. Grease lubricated ball bearings are used below the 30-inch size. Above this size the pump is equipped with babbitt lined sleeve bearings and ball-thrust bearing.

For a copy of Bulletin B-1300 write Peerless Pump Division, Food Machinery and Chemical Corporation, Los Angeles 31, Calif., or Indianapolis 8, Ind., referring to PETROLEUM REFINER item **99.**

Barge Loading Hose

A new line of barge-loading oil hose, announced by The B. F. Goodrich Company and designated as Types 325, 525 and 725, are equipped with Flexseal ends

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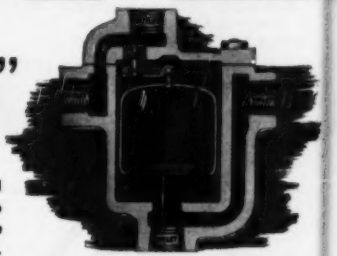
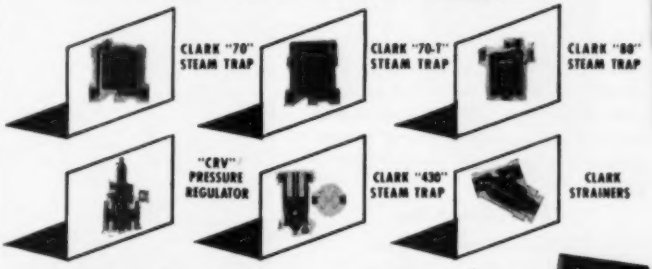
CLARK "60"
STEAM TRAP



The ever increasing demand for the new CLARK "60" Steam Trap proves that Clark engineers "hit the jackpot" again on this one! It is small, costs less, yet it does a *better job* in *more places* than any other trap in its class!

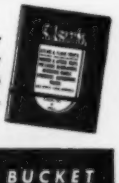
The CLARK "60" is "the small trap with the big trap features" such as positive seating with guided disc. It is equipped with two inlets and two outlets for easy installation on horizontal or vertical lines.

THE CLARK MANUFACTURING CO.
1847 EAST 38TH STREET • CLEVELAND 14, OHIO



Clark

Write today for complete story on Clark Traps and Valves.



TRAPS—*FLOAT, INVERTED BUCKET, OPEN BUCKET AND VACUUM* • REDUCING VALVES • STRAINERS

and split flanges. Type 825, with built-in nipples and flanges, will continue in the line. No gaskets are required in the new hose and the elimination of conventional heavy nipples and flanges brings savings in weight and allows more flexibility. Use of split flanges, not an integral part of the hose, "enables one man to couple a length of hose to a fixed standard flange or to another hose length." Made throughout with oil and gasoline resistant rubber compounds, the hose have a built-in wire which protrudes from the ends for grounding. Sizes range from four to ten inches.

For further information write The B. F. Goodrich Company, Akron, Ohio, referring to PETROLEUM REFINER item **100.**

Coated Fabric Gloves

Sureseal PK coating, a chemical adaptation of Surety Rubber Company's synthetic rubber, "surpasses rubber and all standard synthetics in resistance to virtually all industrial chemicals, including acids, alkalis, oils, petroleum hydrocarbons and solvents, alcohols, ethers, esters, hydraulic fluids, refrigerants, plating solutions, etc." The manufacturer reports its new glove thus shows higher resistance to abrasion and is available in knit wrist, bandtop and 12 and 14-inch gauntlet types.

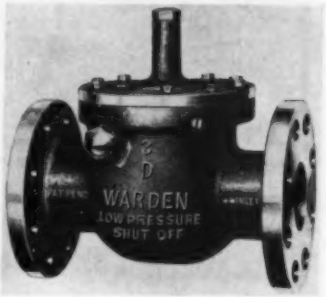
For further information write Surety Rubber Company, Carrollton, Ohio, referring to PETROLEUM REFINER item **101.**

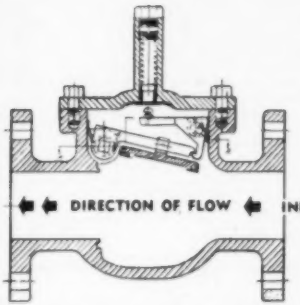
Vacuum Containers

Stainless steel containers incorporating the "latest advances in high-vacuum insulation" have been announced by Emil Greiner Company. Claimed to be absolutely unbreakable, the containers range in size from 11 gallons to one-quart capacity. Each container has double-walled insulation. Illustrated is G14644, which has a capacity of 11 gallons with an inside dimension 22 inches high by 12 inches in diameter to the bottom of the copper recess and an outside dimension 26 inches high by 14½ inches in diameter without the cover. The cover, G14644-A is vacuum insulated, double walled and has a locking hinge.

For further information write Emil Greiner Company, 20-26 North Moore Street, New York 13, referring to PETROLEUM REFINER item **102.**

Shut-off Valve





New improved models of the Warden automatic low pressure shut-off valve

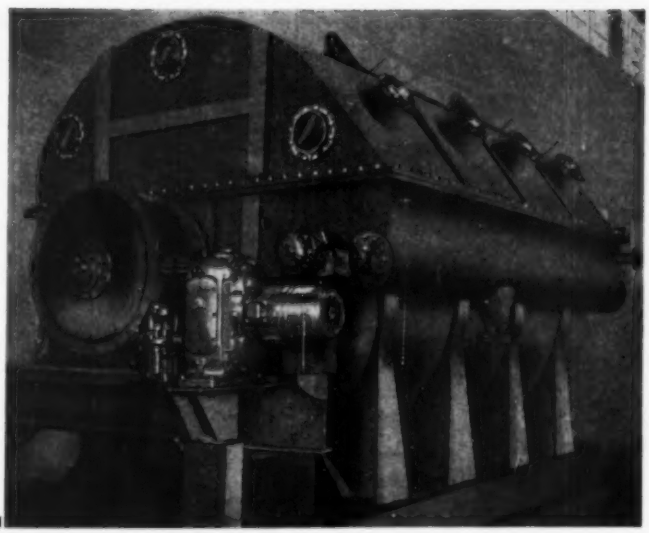
G-B = Guaranteed Buy in dewaxing filters

G-B has designed and manufactured over 150 filters for the petroleum industry for dewaxing oil and deoiling wax. This background of design and manufacturing experience is your guarantee of proven performance and

Low Installed Cost
Low Maintenance Cost
Maximum Time on Stream

• Complete information on request.

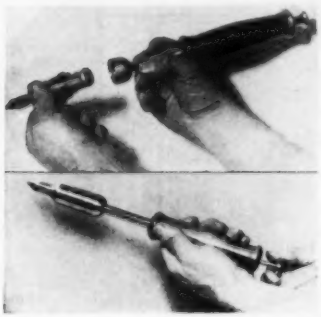
GOSLIN-BIRMINGHAM MANUFACTURING CO., INC.
BIRMINGHAM, ALABAMA
NEW YORK: 350 Madison Ave.



incorporating a precision lapped synthetic rubber seat, which provides for positive closure, are recommended by Security Valve Company for use on gas or fluid lines where closure is desired when pressure fails from any cause. The simple mechanical action is entirely self-contained. Its mechanism is not dependent on external actuating forces. A distinctive feature of the valve is that it must be reset manually after closure. Valves are set to close at pressure specified by the customer and are available in models for both high and low pressure use. They are currently furnished in sizes ¾ through 8 inch.

For a copy of a bulletin describing the valve write Security Valve Company, 410 San Fernando Road, Los Angeles, Calif., referring to PETROLEUM REFINER, item **103.**

Soldering Iron



Requiring no electric current or external heat, the new soldering iron of The Kemode Manufacturing Company, Inc., known as the "Quik-Shot," utilizes a chemical cartridge that "heats the iron to working temperature in five seconds and maintains the iron at an average soldering temperature of 800° F. for seven minutes." The cartridge is ignited by the impact of a spring rod which is pulled out and released at the back of the handle. The heating action is according to the "thermit" process, whereby heat but no gas is generated. Heat developed is equivalent to about 250 watts peak. Six interchangeable tip sizes are available and range from ⅜ to 1⅛ inches.

For further information write The Kemode Manufacturing Company, Inc., 161 West 18th Street, New York 11, referring to PETROLEUM REFINER item **104.**

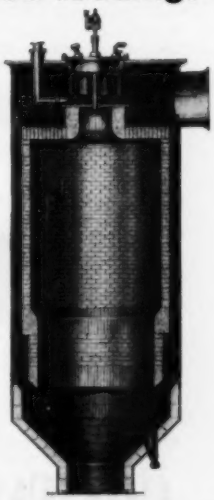
Slide Rule

A slide rule for solving problems in the flow of liquids in pipes and smooth drawn tubing is available from the inventor, Coleman J. Major, who claims the rule will solve the Fanning equation and may be used for calculating pressure drop, pipe diameter or rate of flow for any liquid whose viscosity and

for peak efficiency

on high-pressure furnaces

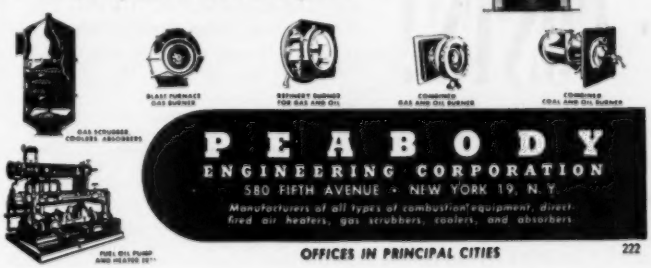
with sustained loadings



PEABODY Direct Fired Air Heater and Burner Units are in service throughout the petroleum industry in every part of the world. Proof that these Peabody units operate to our client's entire satisfaction in various refinery operations is evidenced by the many duplicate installations that we've made for these same clients.

Peabody designs and builds Direct Fired Air Heater and Burner units for operating pressures ranging from atmospheric to 125 lbs. psia and outlet temperatures ranging up to 1800° with firing rates to 100,000,000 BTU per hour. *Specific performance and engineering proposals on request. No obligation.*

HIGH-PRESSURE BURNERS—specially constructed for firing high-pressure furnaces to give dependable performance with special emphasis on stable operation at all times. These burners are designed to burn either gaseous or liquid fuels or both fuels in combination. Wide flexibility permits regulation by simplified central control system.



PEABODY
ENGINEERING CORPORATION
580 FIFTH AVENUE • NEW YORK 19, N. Y.
Manufacturers of all types of combustion equipment, direct-fired air heaters, gas scrubbers, coolers, and absorbers

OFFICES IN PRINCIPAL CITIES 222

WHAT IT COSTS!

What it costs refineries to be safely equipped with AIRETOOL tube cleaners and expanders is insignificant compared to what they save. When these tools are available — your coke removal and expanding problems are readily overcome.

AIRETOOL refinery tube cleaners are especially designed for refinery use. They combine safe, non-tracking new form cutters, powerful motors of slip-fit construction and a variety of cleaning heads suited to meet any condition encountered. Airetool expanders are also designed for simplifying all tube rolling operations. For further information, write THE AIRETOOL MANUFACTURING CO., 316 S. Center Street, Springfield, Ohio.

AIRETOOL Double Expansion Tube Cleaner with Offset Cone Cutter for tubes 3" to 10" I.D.

AIRETOOL G-800 Expander with adjustable ball bearing thrust collar for tubes ½" to 1½" O.D. and for tube sheets ½" to 2¼". Ideal for expanding bi-metal tubes.

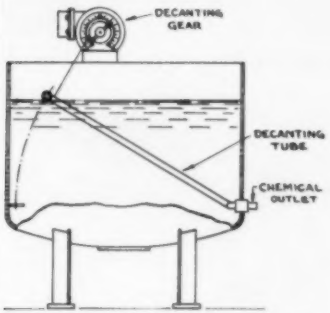
Branch Offices: New York . . . Philadelphia . . . Chicago
Baton Rouge . . . Houston . . . Tulsa

There's an AIRETOOL tube cleaner and expander for every type of tubular construction.

density are known. The rule "solves problems in either turbulent or streamline flow and automatically indicates which type of flow exists in a given problem." Constructed of Vinylite and measuring 10½ by 3¾ inches, the scales cover the viscosity range of 0.1 to 10,000 centipoises, the specific graving of 0.2 to 20, the rate of flow of 0.01 to 100,000 gallons per minute and the pipe diameter of ¼ to 24-inch pipe.

For further information write Coleman J. Major, 2252 15th Street, Wyandotte, Mich., referring to PETROLEUM REFINER item **105.**

Decanting Gear



Worthington Pump and Machinery Corporation announces a new decanting gear used for automatically lowering the swing-pipe decanting tube in the chemical agitating tank to feed chemical to the softener in proportion to the raw water flow. Its operation is paced by the raw water meter. The dial indicates the amount of chemical liquid in the tank and connections are provided for the attachment of an electric low-level alarm. The decanting tube is positioned by a flexible cable attached to the shaped and grooved drum (see drawing). Rotation of the drum pays off cable and lowers the decanting tube. The drum is driven through oil immersed gears by a 1/40 hp synchronous motor inclosed within the housing. The motor is suitable for operation on 110 v, 3 phase, 60-cycle current, although 50 or 25-cycle design can be furnished upon request.

For further information write Water Softener Section, Worthington Pump and Machinery Corporation, Harrison, N. J., referring to PETROLEUM REFINER item **106.**

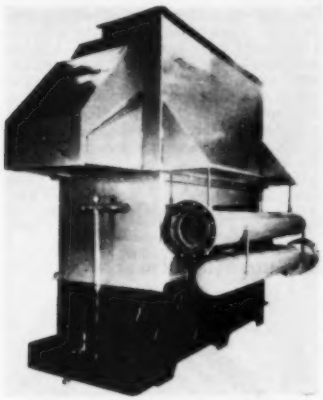
Spectacle-Type Goggle

Watchemoket Optical Company, Inc., has available a new lens design in its Tuc-Away spectacle-type goggle which affords a wearer "92 to 96 percent

protection because a double-duty semi-cup lens design provides full protection at sides and bottom, leaving only a narrow opening at the brow to prevent fogging." Lenses are of shatterproof Impax plastic, optically perfect. Available in clear, light green, medium green and dark green, the goggles have frames of Plexene plastic. The entire goggle weighs less than 5/8 ounce and is recommended for chipping and grinding operations.

For further information write Watchemoket Optical Company, Inc., Providence, R. I., referring to PETROLEUM REFINER item **107.**

After Cooler



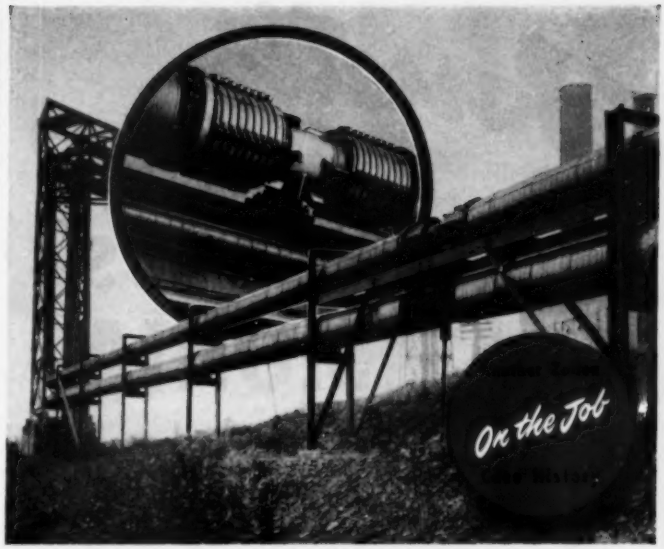
To remove the moisture in its Aero after-cooler that condenses when the compressed air or gas is cooled below the dry bulb temperature of the atmospheric air and to prevent further condensation, Niagara Blower Company has announced that by evaporating a recirculating water spray on the surface of a coil through which the compressed air passes, it can create a temperature close to the wet-bulb temperature of the surrounding atmosphere and lower than the dry bulb temperature and below the summer surface water temperature. Protection against freezing is claimed by use of the "balanced-wet-bulb" control. A thermostat in the spray water reservoir is set for a desired low temperature limit at which it operates dampers to recirculate the air stream internally around a division plate in the center of the unit, instead of drawing in freezing air, permiting outdoor installations.

The Aero After Cooler "consumes less than 5 percent of the cooling water required by conventional coolers." No cooling tower is required.

Complete information may be obtained from Niagara Blower Company, 405 Lexington Avenue, New York 17, by referring to PETROLEUM REFINER item **108.**

Smoke Indicator

Photoswitch Photoelectric smoke indicator, Type A20C-1, announced by Photoswitch, Inc., indicates "the density of smoke passing through the flue or breaching of a heating or power plant, and signals when this density approaches the values prescribed by municipal smoke ordinances." Type A20C-1 consists of a photoelectric control and light source mounted on oppo-



In a Word . . . DEPENDABLE!

HERE is one of several Zallea Stainless Steel Expansion Joints installed in the 250 lb. SWP 450° F. main steam distribution line of the Alan Wood Steel Co., Swedeland, Pa. . . . put there to assure uninterrupted production—and a continuous flow of steam to the mill. This installation is *another* vote of confidence for Zallea Stainless Steel Expansion Joints as the one ideal, *dependable* medium for absorbing movement in pipe lines due to thermal changes. Check these features to see why more and more engineers and designers insist on Zallea when they want the best:

- *More economical than expansion bends*—the cost of insulating and installing a bend alone is frequently more than the cost of a Zallea Stainless Steel Expansion Joint.
- *No maintenance*—having no packing they may be used in underground lines without manholes.
- *Low thrust against anchors*—require only 1/10 the force required to compress some slip type expansion joints.
- *An expansion joint for every type of service*—special types for combined axial and lateral movement.
- *Shorter face to face dimensions*—enables installation in close quarters.
- Hydraulic method of forming assures uniform wall thickness throughout corrugations.
- As easy to install as an ordinary flanged or welding fitting.
- Traverse range from fractions of an inch up to 7½" in a single unit and 15" in a double unit.
- Pressure range from vacuum to 300 lbs. in standard units. Up to 1000 lbs. in special units.
- Temperature range from sub-zero to 1600° F.

Catalog 47 contains complete information on all Zallea Expansion Joints. We would be pleased to send you a copy. Write today: Zallea Brothers, 890 Locust Street, Wilmington 99, Delaware.

Zallea
EXPANSION JOINTS

WORLD'S LARGEST MANUFACTURERS OF EXPANSION JOINTS EXCLUSIVELY

Barrett

ANHYDROUS AMMONIA

...Low-Cost Neutralizer for Petroleum Refining

BARRETT ANHYDROUS AMMONIA, shipped as a concentrated liquid with a guaranteed minimum purity of 99.5% NH_3, is one of the lowest cost neutralizing agents delivered to the refinery. Because of its low molecular weight, one pound of Ammonia will neutralize the same quantity of acid as several pounds of other neutralizing agents.

Easily vaporized, Anhydrous Ammonia follows the gas stream through the refinery equipment, neutralizing corrosive acids as they are formed. Ammonia has high solubility and a high rate of diffusion in oil.

Used in oil refining, Ammonia destroys acidity without the formation of water or undesirable emulsions. Products of neutralization can be easily removed from the oil. Excess Ammonia can be removed by blowing the oil with air. Used as a liquid or as a gas, Ammonia is easy to handle in the refinery.

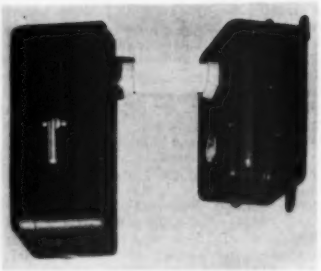
Barrett Standard Anhydrous Ammonia is available in 50, 100 and 150-pound cylinders from stock points conveniently located from coast to coast.

The advice and help of Barrett technical service men are available to Barrett customers without charge. Free literature on Barrett Anhydrous Ammonia will be mailed on request.

Barrett

THE BARRETT DIVISION
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N.Y.

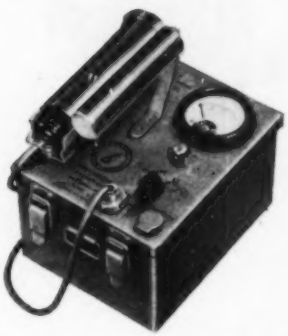
BARRETT PRODUCTS HAVE SERVED AMERICAN INDUSTRY SINCE 1854



site sides of the flue, with the light source beam projected across the flue onto the photoelectric control. Supplementary equipment available includes bell alarms to signal excessive smoke, densimeters to give continuous indications of smoke density, recorders to record the time of day at which excessive indications of smoke density, and recorders to record the time of day at which excessive smoke passes through the stack.

For a copy of Bulletin PE 478 write Photeoswitch, Inc., 77 Broadway, Cambridge 42, Mass., referring to PETROLEUM REFINER item **109.**

Portable Geiger Counter



A new portable geiger counter, developed by Precision Radiation Instruments, Inc., measures low energy beta particles and alpha particles as well as gamma and X-ray radiations. The meter contains a thin end mica window counter with a 1.5 mg/cm² window which enables it to detect Carbon 14 and other radio-active tracers. The tube is "self-quenching with a geiger threshhold at 825 plus or minus 25 volts and a 200 volt plateau and is mounted inside a specially designed probe which enables it to distinguish between alpha, beta and gamma radiations." The entire probe assembly and waterproof cable is mounted on a box 5¼ x 6½ x 4½ inches, weighs about seven pounds, has a plug-in circuit for servicing and a battery life in excess of 400 hours.

For further information write Precision Radiation Instruments, Inc., 1101 North Paulina Street, Chicago 22, referring to PETROLEUM REFINER item **110.**

Ball Type Inner Valve

A ball type inner valve to give accurate regulation, greater capacity and

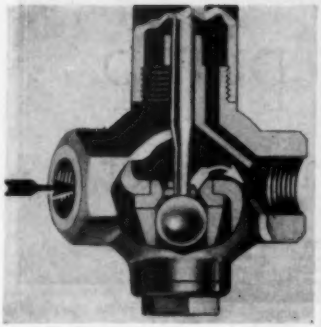
AMMONIA
(Refrigeration Grade)

TANK CARS and CYLINDERS

direct service from producing point to user available on contract shipments or spot orders from...

SPENCER CHEMICAL COMPANY
Executive and Sales Offices
612 Dwight Building
Kansas City 6, Missouri

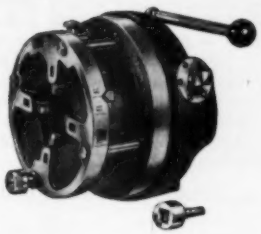
CONTACT SPENCER NOW FOR 1949 CONTRACTS



tight closing has been designed by Klipfel Manufacturing Company. The new inner valve construction appears in all of the Klipfel "400" valve series in applications which require accurate regulation of steam, water, air or gas at inlet pressures less than 250 pounds, reduced pressures below 150 pounds and where the reduced pressure must be adjusted frequently. They are single seated with a stainless steel ball inner valve actuated by a rubber diaphragm. The ball centers freely on the seat with uniform contact all around, closing tightly the moment it seats. When off the seat the ball is free to turn so that all parts are exposed in turn to the action of the flow. Any wear which may occur in time will be evenly distributed.

For a copy of Bulletin 140-S, write Klipfel Manufacturing Company, Hamilton, Ohio, referring to PETROLEUM REFINER, item **111.**

Pipe Threader



Armstrong Brothers Tool Company's new No. 165 portable power pipe threader is operated by any ½-inch standard electric drill, and will thread 1, 1¼, 1½ or 2-inch pipe with one set of high speed steel chasers. Weighing only 26 pounds, the threader is furnished with one set of high speed chasers and drive adapter.

For further information write Armstrong Brothers Tool Company, 5200 West Armstrong Avenue, Chicago 30, referring to PETROLEUM REFINER item **112.**

Purge Meter

Gas or liquid purge rates are measured in familiar flow units (i.e. cubic feet per hour of air or gallons per hour of water) by the new purge service flowmeter of Fischer & Porter Company. The "bubbler type" purge meter is an adaptation of the flowrator instrument

SIDE ENTERING MIXER FOR OILMEN

Eastern side entering agitators are specially engineered for large tank installations. Material tending to settle during mixing is kept in motion by the propeller; bottom precipitation is thus prevented. Cast ribbed bases supporting motor and stuffing box insure rigid alignment — eliminate wear and leakage.

These heavy duty mixers are available with pressure stuffing box, twin rotary seal or mechanical rotary seal; also with outboard stuffing box which can be repacked without emptying tank. They're powered with motors rated from ¼ to 30 H.P., with rotating speeds from 400 to 1725 R.P.M.

WRITE FOR FULL DETAILS

Eastern
INDUSTRIES, INC.
20 REGENT STREET
EAST NORWALK, CONN.

no other pump
has so much to offer...
No destructive casing erosion or corrosion
Exact hydraulic and mechanical balance, light weight rotor, large bearings, result: bearing troubles practically unknown
All parts made to gauge and replaceable without fitting; all parts in stock at factory with wearing parts available from agencies' stocks
High efficiency pump plus high speed two-bucket row turbine results in minimum steam consumption
Proved for performance over a period of more than twenty years in service
Pump gland leaks@ provides adequate recirculation; suction pressure only on packing
Loss of suction reduces speed without tripping, automatic speed recovery with suction restoration
Rigid one-piece steel casing plus heavy shaft plus ample clearances result in no damage from dry operation
Matched Pump, Turbine and Governors under one responsibility
Compact, light in weight, quiet and low in maintenance
Wide range exact pressure governing
No interstage leakage

compact . . . noiseless . . . vibrationless

10,000 hours continuous operation between inspections!

LEADING engineers in industry today look for better and more efficient equipment to cut costs AND boost production efficiency. That's why Coffin Turbo Pumps are being specified on an increasing number of jobs — *they deliver more dependable performance than any other comparable pump on the market.* Backed by more than 20 years experience, Coffin Pump specifications have been proved time after time on hundreds of installations. Check these specifications in your files the next time you want *real* pump performance — steam pressures to 850 psi . . back pressures to 200 psi . . pump capacities to 500 gpm . . . discharge pressures to 1100 psi . . heads to 2400 feet . . liquid temperatures to 300°F . . .

Complete description of Coffin Turbo Pumps are available on request or in the ASME Catalog or Sweet's File.

Specific proposals and application suggestions are available without obligation on receipt of operating data.

A complete 4-page illustrated bulletin on COFFIN TURBO PUMPS with all operating data, applications, specifications that you may require for your next job. Write for Bulletin "S" today.

REPRESENTATIVES IN PRINCIPAL CITIES.

INDUSTRIAL • RAILROAD • MARINE PRODUCTS

162

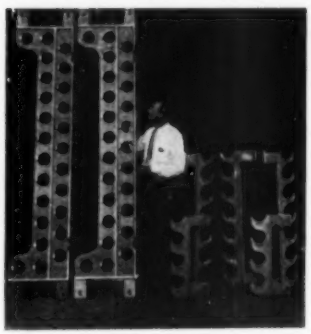
The J. S. COFFIN, JR., COMPANY

326 SOUTH DEAN STREET, ENGLEWOOD, NEW JERSEY

that includes a built-in needle valve for close control of purge rates. It covers the range of measurement generally accepted as standard for bubbler installations. The unit consists of a Pyrex or stainless steel ball-shaped float, a precision-bore Pyrex metering tube and a die-cast body which houses the needle-type control valve.

For a copy of Bulletin 1C-O, write Fischer & Porter Company, Hatboro, Penn., referring to PETROLEUM REFINER item **113.**

Refinery Castings



Tube supports, sheets and hangers of chromium-nickel alloy castings and stainless steel castings for hot oil pumps and valve members are illustrated and described in a Fahralloy bulletin.

For a copy write The Fahralloy Corporation, Harvey, Ill., referring to PETROLEUM REFINER item **114.**

Automatic Extinguisher

Stop-Fire, Inc. announce the Underwriters' Laboratories listing of its automatic sprinkler portable system fire extinguisher, constructed of heavy brass, silver welded, that "needs no piping or other elaborate installation." Flame does not have to touch this unit for operation. When fire occurs, heat waves cause an approved sprinkler head (like those on automatic sprinkler water systems) to discharge under pressure a wide spray of combined carbon dioxide and atomized chlorobromethane. This "blankets and snuffs the fire, leaving no residue or stain damage." Intended for use on oil,

grease, flammable liquid, or electrical fires, the unit is non-freezing and has the minimum specification capacity of 700 cubic feet.

For detailed information write Stop-Fire, Inc., 125 Ashland Place, Brooklyn 1, N. Y. referring to PETROLEUM REFINER item **113.**

Galvanic Cell Corrosion

Reasons for galvanic cell corrosion, as well as methods for helping to overcome it, are contained in a new booklet issued by The International Nickel Company.

For a copy of the booklet write The International Nickel Company, Inc., 67 Wall Street, New York 5, referring to PETROLEUM REFINER item **114.**

Control Instruments

Leeds and Northrup Company's line of Speedomax instruments, indicators, indicating recorders and recording controllers, is described and illustrated in Catalog ND48 (1). The pyrometers listed are supplied for measuring temperature with thermocouples, Rayotubes or Thermohms. The recording controllers are offered for two-position control or are integral parts of full-proportional control system. Design features, schematic diagrams of the Speedomax potentionmeter and Wheatstone bridge circuit and sections of a round chart and a strip chart with the type of record available for each are illustrated.

For a copy of the catalog write Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, referring to PETROLEUM REFINER item **115.**

Dryer and Flaker

F. J. Stokes Machine Company has announced the new Stokes Model 214-A dryer and flaker especially designed for pilot plant use. Used as a double or single drum dryer by separating the drums and rotating only one, it can also be used as a twin drum by rotating the drums in the opposite direction and feeding from below. Complete instrumentation permits "exact recording of data and control of all variables while making tests." Stamped in accordance with ASME code for 160 psi. maximum steam working pressure, the drums can be either heated with steam or other suitable heating mediums, or cooled with water. Drum drive has a 24:1 speed range, with drive reversible for use with all types of feeds. A drum speed indi-

For Corning Mill Supply Glassware phone your nearest industrial distributor

Gauge and sight glasses aren't missed until you need one in a hurry. Wise buyers see to it that an ample supply of Corning glassware is kept on hand, ready for any emergency.

But if for any reason you need gauge or sight glass in a hurry, just phone your nearest industrial distributor. He is equipped to give prompt delivery on Corning's complete line of mill supply glassware.

By asking for Corning products, you get the best. By test and by experience, they have proved most economical. Check the points below, and you'll see why it will pay to order from the nearest industrial distributor today.

T.M. REG. PYREX U.S. PAT. OFF.

Exclusive Features of Corning Gauge Glasses

1. PERFECT VISIBILITY—Pyrex and Corning brand gauge glasses are crystal clear. Water level is *always* easy to see. Pyrex red line gauge glass magnifies the water level.
2. LONG SERVICE LIFE—Because of their composition and method of manufacture, Pyrex and Corning brand gauge glasses withstand expansion, contraction and physical shock to a greater degree than comparable products.
3. EASY TO INSTALL—Accurately controlled manufacture assures uniformly close tolerances for accurate fit.
4. MEET ALL SERVICE CONDITIONS—Whether your pressure requirements are high or low, Corning has the gauge glass that will meet them.

CORNING GLASS WORKS · CORNING, N.Y.

Sales Offices: NEW YORK, CHICAGO, SAN FRANCISCO

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TECHNICAL PRODUCTS DIVISION · HOUSEWARES · LABORATORY GLASSWARE · OPTICAL GLASS · GLASS COMPONENTS

cator, claimed to be the first ever installed on a drum dryer, eliminates the use of stop watch for every change in rpm. Instruments indicate drum clearances in thousandths of an inch and "can use all commercially practical types of knives."

The Model 214-A dryer and flaker instrument panel includes control and indicating recorders for drum steam pressure, power consumption and drum speed for drying operations; cooling water outlet temperatures and cooling water flow rate for chilling or flaking operation; and drum drive motor control, feed pump control, vapor hood exhauster motor controller.

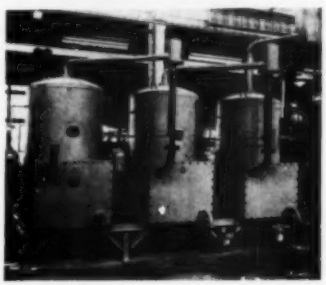
For further information write F. J. Stokes Machine Company, 5900 Tabor Road, Philadelphia 20, referring to PETROLEUM REFINER item **116.**

Wide Range Power Apparatus

A new wide range power supply apparatus which features "a continuously variable voltage output from 500 to 50,000 volts with a maximum current output of one milliampere" has been announced by General Electric. The high voltage is attained through the use of a radio frequency oscillator, power amplifier, RF transformer and a ladder-type voltage tripler circuit. Use of the RF source, about 40 kc, "reduces the output ripple to a low value by simple filtering means." Output power, supplied through a 15-foot X-ray cable "is not affected by variations in line voltage or frequency." Compensation "is made for ambient temperature changes and precision regulation is attained through the use of two regulating loops in cascade." A switch provides for the selection of two ranges, 500 to 5000 volts and 5000 to 50,000 volts. A gravity-operated grounding device shorts the output terminals when the high voltage is turned off. Power requirements are 100-130 volt rms, 60 cycles, with commercial stability. Full load power consumption is approximately 1000 watts.

For further information write General Electric Company, Schenectady 5, N. Y., referring to PETROLEUM REFINER item **117.**

Vacuum Water Stills

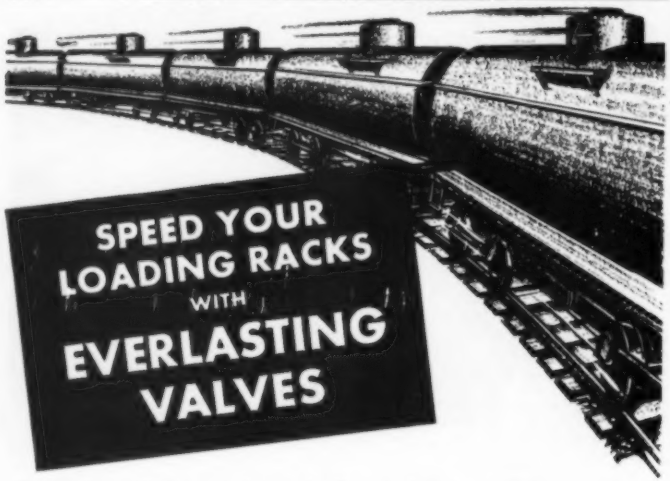


F. J. Stokes Machine Company's new multiple effect vacuum water still can be operated by steam at low pressures discarded by plants. Models range in capacity from 150-1000 gallons per hour. Special features are the high heat transfer coefficient through the design characteristics of the inside and outside calandrias and the use of special double centrifugal entrainment separators, "assuring water of highest purity." The stills are supplied complete with fully automatic controls "arranged to maintain a constant level in the distilled water storage tank." The conductivity of the distilled water coming from the still is also automatically recorded.

For further information write F. J. Stokes Machine Company, 5900 Tabor Road, Philadelphia 20, referring to PETROLEUM REFINER item **118.**

Power Sockets

Recent additions to the Impact "Supersocket" line of power wrenches, manufactured by J. H. Williams and Company, have increased the number of power sockets in the various styles and sizes to over 150, making the line adaptable "to all socket locking methods used on the various types and makes of power and impact wrenches." Made of



Handling gasoline on refinery loading racks, these EVERLASTING Valves reduce lay-over time on scarce transportation equipment for 3 reasons:

1. No time lost turning slow-acting valve handwheels. An easy, short-stroke push on the valve lever, and EVERLASTING Valves open wide or close tight—INSTANTLY.
2. No pressure losses. When wide open, EVERLASTING Valves have straight-through flow—unimpeded by valve discs or other interior obstructions.
3. No maintenance expense. Every time an EVERLASTING Valve is opened or closed, the self-lapping action of the valve disc on its seat maintains the drop-tight seal during a long life.

The many thousands of EVERLASTING Valves on gasoline and other services in the petroleum industry *prove* their many time-saving, money-saving features. Write for descriptive bulletin.

EVERLASTING Lever-operated Valve — for handling pressure or vacuum services where a drop-tight quick-acting valve is required.

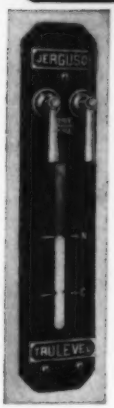
EVERLASTING VALVE CO., 49 Fisk St., Jersey City 5, N. J.

Everlasting Valves

Trade-Mark "EVERLASTING" REG. U. S. PAT. OFF.

for everlasting protection

Here's A Better Way To Read Water Levels Of Inaccessible Boiler Drums!



Use New

JERGUSON TRULEVEL GAGES

For All Distant Reading Problems

JERGUSON TRULEVEL Gages are the ideal solution to your problem when you need to read boiler water level accurately at a distant point, as in the case of inaccessible waste heat boilers.

TRULEVEL brings the liquid level reading of water, or of any condensing medium which you may be using, right down where you can see it. Complete accuracy of reading is assured by the use of a new type datum column, located at the drum.

Quick checking at the distant reading point is another important feature of TRULEVEL, and this is patented and exclusive with Jerguson. By simply turning the two valve handles on the cover it is possible to check gage accuracy *in a matter of seconds*. For accuracy and safety use the Jerguson TRULEVEL.

IMPORTANT! Manometric fluid used in TRULEVEL Gage is color fast! Simple to maintain. No leakage. Another important feature of Jerguson TRULEVEL Gages.

Write for Jerguson Trulevel Data Unit No. 38, without obligation, today!

JERGUSON GAGE & VALVE COMPANY

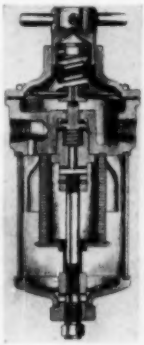
100 Fellsway, Somerville 45, Mass.

Representatives in Major Cities
Phone Listed Under JERGUSON

alloy steel, specially heat-treated to "withstand the constant shock and pounding involved in electric and pneumatic impact nut setting or power nut running," the "supersockets" are available in seven-square drive sizes with hex openings from 3/16 to 3½ inches and eight-point openings from 5/16 to 1¼ inches in regular and bolt clearance lengths.

For a copy of Booklet A-100 write J. H. Williams and Company, 400 Vulcan Street, Buffalo 7, N. Y., referring to PETROLEUM REFINER item **119.**

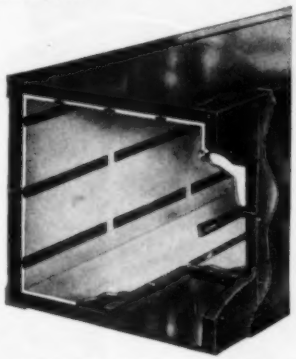
Regulator-Filter



Combining the features of a reducing-relief valve and an air filter, Model FH-15 combination regulator-filter of Conoflow Corporation has a diaphragm area large enough "to provide accurate regulation regardless of variations in demand load." Filter medium is a phenolic-resin impregnated cellulose cylinder capable of "removing particles as small as 40 microns." It can be cleaned by dipping into a solvent material such as gasoline. All filtering takes place on the high side of the regulator. Below the filter element is a dripwell for oil and water. Removal of the filter element is possible by loosening and removing only one nut. Replacement can be made with the unit installed in the line.

For further information write Conoflow Corporation, 2100 Arch Street, Philadelphia 3, referring to PETROLEUM REFINER item **120.**

Insulation



Announcing its new product, "Insuliner", M. W. Detrick Company claims this insulation for breechings, flues, ducts, and hot vessels can be applied in the field without outside engineering assistance and that it provides a definite means of securing the insulation to the steel shell, protects the surface of the insulation and stops maintenance because it is all properly supported. A block insulation supported by a system of bars held in position by bolts welded

Ask about our new service on conversions, alterations and new construction—with ONE RESPONSIBILITY, ONE RELIABLE FIRM—from design through installation and construction. Complete staff of electrical engineers and specialists. We work with your engineering firm, general contractor or direct.

KELSO-BURNETT ELECTRIC COMPANY

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K·B SERVING INDUSTRY SINCE 1908

CHICAGO 6, ILLINOIS

to the steel shell is covered with an Insuliner cement which protects the insulation and resists a reasonable amount of abrasion.

For further information write M. H. Detrick Company, 111 West Washington Street, Chicago 2, referring to PETROLEUM REFINER item **121.**

Filters

Laboratory and pilot plant filters of Oliver United Filters, Inc., are illustrated and described in Bulletin 251-R. Characteristics of the eight filters are listed and the principle of operation is presented.

For a copy of the bulletin write Oliver United Filters, Inc., 33 West 42nd Street, New York 18, referring to PETROLEUM REFINER item **122.**

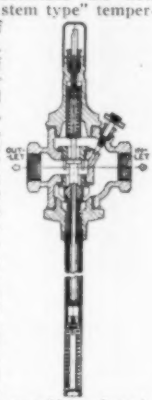
Alarm Systems

"Panalarms," multiple signal and alarm systems manufactured by Panalarm Products, Inc., are used where sound and visual alarms are required to indicate failure or changes off normal. They may be actuated by any type of equipment which can be reflected by an electric impulse to open or close a small relay. The lamps glow dimly during normal operation, but when there is an abnormal condition, two signal lights go on and a warning is sounded. Many combinations of lights and signals are available to indicate the trouble line and to indicate when corrective measures have been taken. Each cabinet contains a wiring strip capable of receiving any combination of the various alarm units.

For a copy of Bulletin 300 series write Panalarm Products, Inc., 7218 North Clark Street, Chicago 26, referring to PETROLEUM REFINER item **123.**

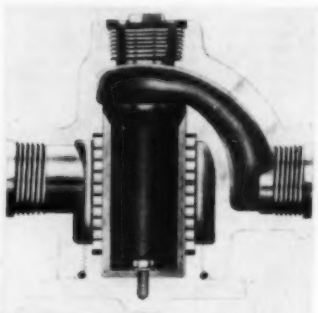
Temperature Regulator

Bulletin S-1289 describes the new "self-operated, rigid stem type" temperature regulator of Sarco Company, Inc. Limiting the flow of cooling water through engine and compressor jackets, hydraulic presses, vapor degreasers and condensers in order to maintain constant temperature, it is the type where the warm water flows over the bulb which is attached to a valve in the cold water supply, piped to the bulb location. Danger of sticking or chattering is eliminated "with closely balanced, double seated valves which provide accurate control." A separable socket allows the regulator to be removed for inspection without interrupting operation. It is available in ⅜ to 1½ inch sizes for water pressures to 150 psi.



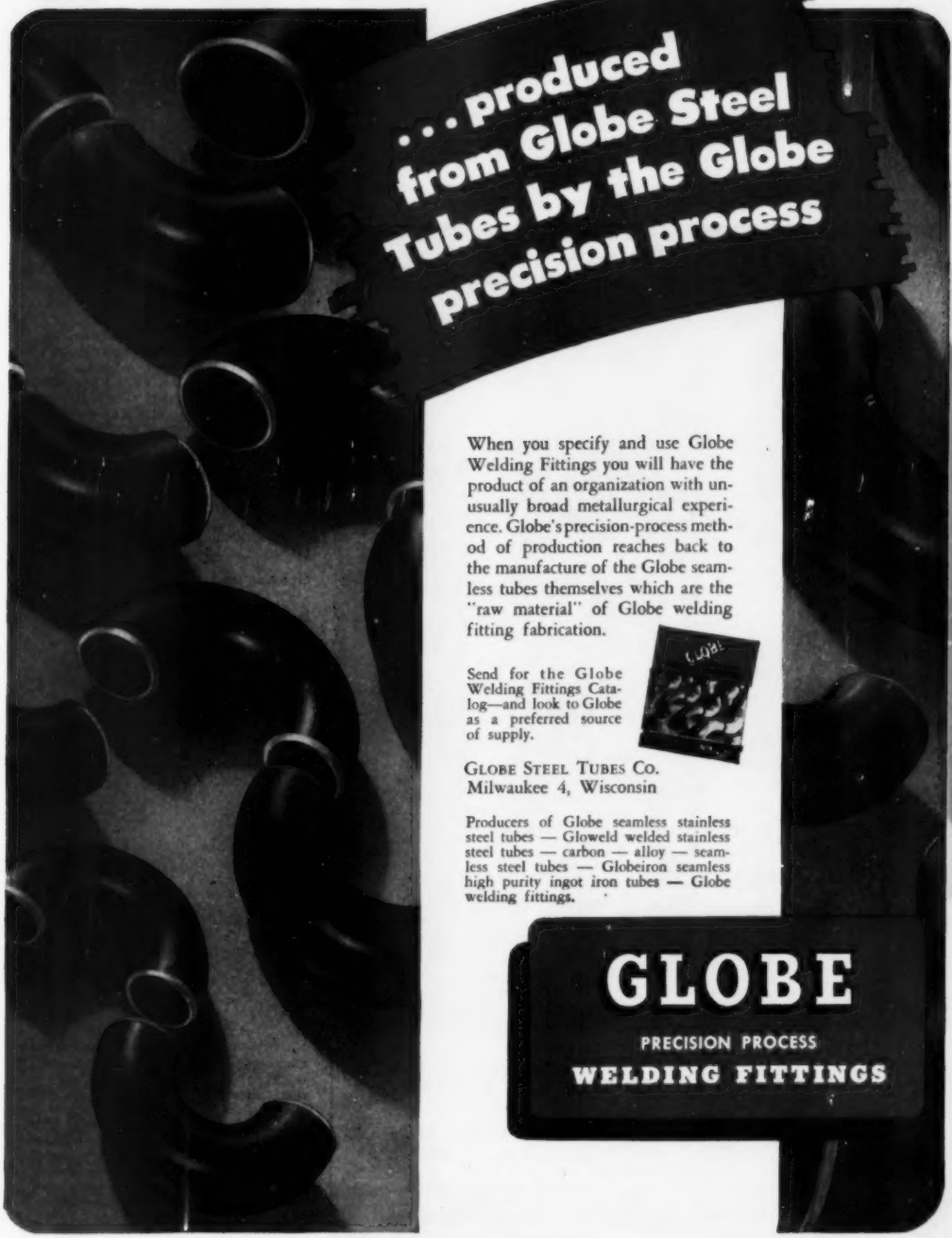
For a copy of the bulletin write Sarco Company, Inc., Empire State Building, New York 1, referring to PETROLEUM REFINER, item **124.**

Check Valve



Val Corp's new type check valve, eliminates "many of the difficulties encountered by conventional valves, giving a positive seal even after sealing surfaces have been damaged by corrosion or fluid cutting and sealing successfully even against paraffin deposits." The valve is "easily repaired because, instead of replacing the entire valve, the bonnet may be removed for replacing the screen and packer cup." Other claims

GLOBE WELDING FITTINGS



. . . produced from Globe Steel Tubes by the Globe precision process

When you specify and use Globe Welding Fittings you will have the product of an organization with unusually broad metallurgical experience. Globe's precision-process method of production reaches back to the manufacture of the Globe seamless tubes themselves which are the "raw material" of Globe welding fitting fabrication.

Send for the Globe Welding Fittings Catalog—and look to Globe as a preferred source of supply.

GLOBE STEEL TUBES CO.
Milwaukee 4, Wisconsin

Producers of Globe seamless stainless steel tubes — Gloweld welded stainless steel tubes — carbon — alloy — seamless steel tubes — Globeiron seamless high purity ingot iron tubes — Globe welding fittings.

GLOBE
PRECISION PROCESS
WELDING FITTINGS

include: no moving metal parts, no seats, no "clatter", 100 percent coefficient of flow, low pressure drop, no hammer and the valve can be installed in the line or as an "ell." A complete range of sizes, materials and pressure ratings is available.

For further information write Val Corp, 4015 Leffingwell, Houston, referring to PETROLEUM REFINER item **125.**

Percolation Clay

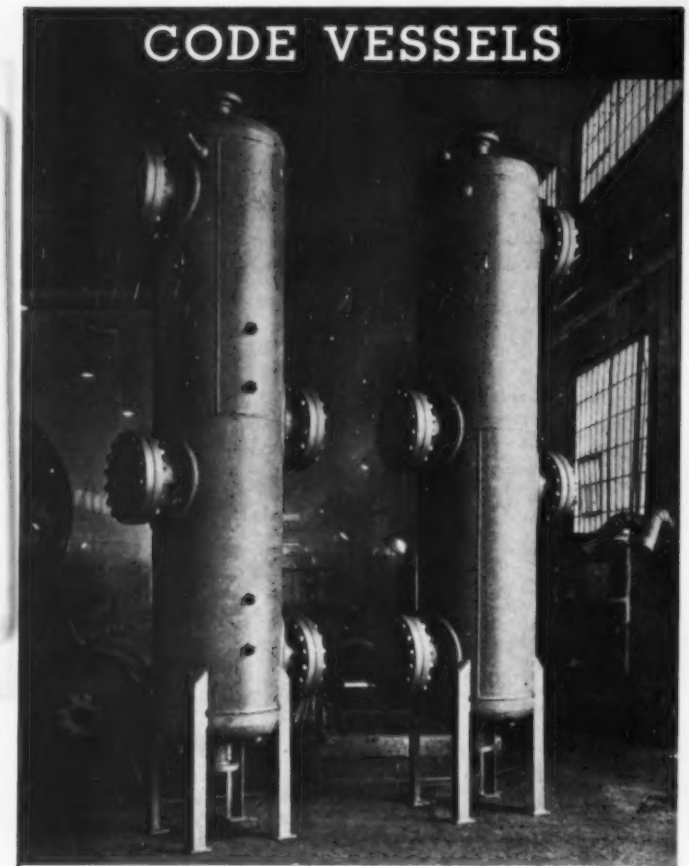
Attapulgas Clay Company is offering a new granular high-efficiency fullers earth, Attapulgus AAA grade clay, for percolation filter house use. Claimed for AAA is its ability to reduce clay costs 15 to 25 percent for, with most oils, "it displays 10 to 20 percent more refining efficiency and maintains this increase over its life." It also is claimed to have a higher yield per ton. The clay is available in standard percolation meshes.

For further information write Attapulgus Clay Company, 210 West Washington Square, Philadelphia 5, referring to PETROLEUM REFINER item **126.**

Electric Hoists

Wright Hoist Division of American Chain and Cable Company, Inc.'s new folder, DH-65, describes its new advanced design line of electric hoists. It includes "the 21 points of superiority" of Wright electric hoists, action photographs, illustrations, cross section views and complete specifications.

For a copy write Wright Hoist Division of American Chain and Cable Company, Inc., York, Pa., referring to PETROLEUM REFINER item **127.**



LEADER BUILDS
TANKS — KETTLES — FRACTIONATING COLUMNS
HEAT EXCHANGERS and SPECIAL EQUIPMENT
OF
STEEL — STAINLESS STEEL — NICKEL — MONEL
INCONEL — COPPER — EVERDUR — HERCULOY
HASTELLOY — ALUMINUM and CLAD STEELS

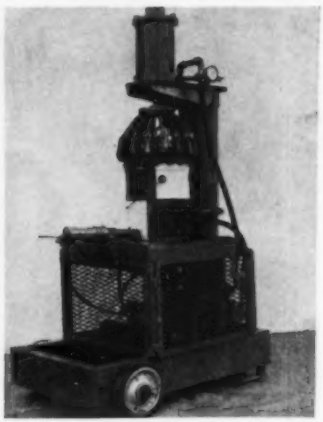
LEADER IRON WORKS, INC.
2170 N. JASPER DECATUR, ILLINOIS

Spark Protractor

A new electronic spark protractor that measures the average spark advance of 6- and 8-cylinder engines is announced by Photocon Research Products. The protractor's dial has 250° of arc, scaled to record from 10° retard to 60° advance. Claimed to be accurate to plus or minus ½ degree, each instrument is individually calibrated to provide maximum accuracy. It operates directly for 6-volt battery, "yet measurements are unaffected by engine speed or battery voltage." It is also furnished in combination with a tachometer for measuring engine rpm.

For further information write Photocon Research Products, 1062 North Allen Avenue, Pasadena 7, Calif., referring to PETROLEUM REFINER item **128.**

Grease Pail Crimper



A machine which automatically crimps the lid on grease, paint and other viscous liquid containers, developed by Barrett Manufacturing Company, is made for use on all sizes of pails which have removable tops and is designed to handle up to 720 pails per hour with "no manual operation involved." It is used in conjunction with the Barrett automatic filler. Using compressed air for power, the operator feeds the empty cans into the filling machine and rollers carry them directly to the crimper. The can is automatically ejected from the filling machine when full, with "less

than four ounces variation in weight in 25 or 30 pound pails."

For further information write Barrett Manufacturing Company, P. O. Box 8096, Houston 4, referring to PETROLEUM REFINER item **129.**

Steel Tubing Data Cards

The Babcock and Wilcox Tube Company has available new editions of five tables dealing with steel tubing as follows: 115, "Tolerance of Round Seamless Steel Mechanical Tubing," giving permissible variations in diameter and wall thickness for cold-drawn unannealed and finish-annealed and for hot-finished tubing; 112, "Metric Conversion Table," a handy reference which converts millimeters to decimals of an inch; 110, "Linear Conversion Table," giving the relation of inches and fractions of inches to decimal parts of a foot; 103, "Wall Thickness Data for Seamless and Welded Tubing," showing wire and sheet metal gauge equivalents, in inches and millimeters; and 125, "Hardness Conversion Tables," giving the approximate relation between hardness by various testing systems (Rockwell, Vickers, Shore and Brinell) and tensile strength of carbon and alloy steels.

For data cards write The Babcock and Wilcox Tube Company, Beaver Falls, Pa., referring to PETROLEUM REFINER Item **130.**

Refractories

Information on 3X Blazecrets for gunning and patching the 3X Firecrete for casting special shapes is contained in a folder on refractories by Johns-Manville. Included are recommended uses and technical data such as cold compressive strength, modulus of rupture, percent linear change and yield per pound.

For a copy of the folder write Johns-Manville, 22 East 40th Street, New York 16, referring to PETROLEUM REFINER item **131.**

Fan-Cooled Motors

Features of a totally enclosed fan-cooled motor by Allis-Chalmers Manufacturing Company with tube-type air-to-air heat exchangers are described in Bulletin 05B7150. The manufacturer claims that the problem of efficiently removing heat losses without exposing electrical parts to harmful atmospheric conditions has been solved in these motors. Ratings of the motors, available in squirrel cage, wound rotor and synchronous types, for vertical or horizontal installation, range from 150 hp. at 1200 rpm to several thousand horsepower, at standard speeds of from 3600 rpm to about 300 rpm. With some modifications, they can be made explosion-proof.

For a copy of the bulletin write Allis-Chalmers Manufacturing Company, 1126 South 70th Street, Milwaukee, Wis., referring to PETROLEUM REFINER item **132.**

Heat Exchangers

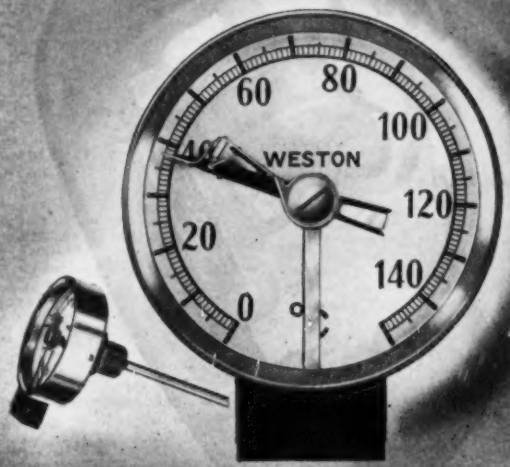
The design and service of four types of heat exchangers using "Karbate" as protection against corrosive fluids and gases are featured in a brochure by Foster Wheeler Corporation. Other applications of "Karbate" are as an HCl absorber, an ejector for producing a high vacuum and a standard heat exchanger for use in pilot plants and small volume processes. Physical properties of "Karbate" and a table giving its resist-

NEW—

all-metal WESTON

Contact-making

thermometer



This new Weston combines the features of an indicating device with the advantages of an alarm or control instrument. A contact arm, mounted as shown above, is easily set to make contact at any temperature on the scale.

A terminal block on the periphery of the case makes electrical connection easy. The thermometer is all-metal, typically WESTON in ruggedness and reliability, with accuracy of ±1% as an indicating thermometer, and ±1½% as a contact making device. It is supplied in two types—for operation on either increasing or decreasing temperatures.

For complete information see your local WESTON representative or write Weston Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON

Thermometers

PIPE CUTTING

Made Easy!

RIDGID Cutter assures clean cuts, fast, with least effort

● Slap this sturdy RIDGID cutter on a pipe and roll it right through in a few easy turns, with surprisingly little effort. Efficiency-balanced, it handles easily. The tool-steel thin-blade cutter wheel sinks cleanly through pipe and conduit, leaves practically no burr—every RIDGID cutter is factory-tested to make sure it tracks perfectly. Your choice of 5 sizes to 6" pipe; 4-wheel cutters to 4." Buy RIDGIDs at your Supply House.

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WORK-SAVER PIPE TOOLS

THE RIDGE TOOL CO. • ELYRIA, OHIO

ance to a large number of acids, salt solutions, alkalies, organic compounds and gases and mixtures are also given. Illustrations are of heat exchangers designed by Foster Wheeler.

For a copy of the brochure write Foster Wheeler Corporation, 165 Broadway, New York 6, referring to PETROLEUM REFINER item **133.**

Chemical Packaging

A new booklet, "Packing for the Chemical Industry," has been prepared by Crane Packing Company. Designed to give a picture of packing requirements for practically all chemical application, the book describes and illustrates each "John Crane" style and recommends specific services and temperatures. Chemlon, the new Crane development in chemically inert packings has a special feature. The material is completely inert in most chemicals with the exception of molten alkali metals.

For a copy write to Crane Packing Company, 1800 Cuyler Avenue, Chicago 13, referring to PETROLEUM REFINER item **134.**

High Vacuum and Atmospheric Processing

F. J. Stokes Machine Company's Catalog 49-C is devoted to higher vacuum and atmospheric processing equipment. The redesigned Stokes drum dryers, rotary vacuum dryers and flakers are featured. Also described are the Stokes semi-plant and laboratory equipment and the confidential advisory service and demonstration laboratory facilities available.

For a copy write F. J. Stokes Machine Company, 5900 Tabor Road, Philadelphia 20, referring to PETROLEUM REFINER item **135.**

Air Compressors

Worthington Pump and Machinery Corporation has available a new selection chart on water-cooled air compressors, based on normal applications handling air with atmospheric intake pressure. The chart compares discharge pressure pounds per square inch gage and piston displacement cubic feet per minute. It also recommends compressor bore and stroke in inches.

For a copy of the chart write Worthington Pump and Machinery Corporation, Harrison, N. J., referring to PETROLEUM REFINER item **136.**

Forging

Drop Forging Association's reference data booklet describes the development of metal quality from the blast furnace to the finished forging. Proper selection of metals for forgings, steps in making forging dies and various methods and equipment used in hot working steel by forging are presented. Various forging procedures also are outlined.

For a copy of the booklet write Drop Forging Association, 605 Hanna Building, Cleveland 15, Ohio, referring to PETROLEUM REFINER item **137.**

Axial Flow Compressors

Available in either electric, steam or gas turbine drives, the axial flow compressor of Clark Brothers Company, Inc., has the "advantages of high efficiency, reduced floor space, light weight, low maintenance and high temperature

rise without intercooling." They are designed for application in the volume range from 20,000 to 300,000, and in standard units adiabatic temperature rise efficiencies up to 85 percent are obtainable. For atmospheric air, discharge pressures up to and including 100 psig, may be obtained in single units.

For a copy of a recent bulletin write Clark Brothers Company, Inc., Olean, N. Y., referring to PETROLEUM REFINER item **138.**

Flame Failure Safeguard

For flame failure protection of semi-automatic and manually ignited industrial oil burners, Combustion Control Corporation has introduced Fireye System FF-3, which includes a photoelectric scanner and control. The scanner consists of a phototube and vacuum tube amplifier mounted on the burner mounting plate so that it has a clear view of the oil flame. The control consists of two relays and a power transformer mounted on the burner control panel. It includes a safety start circuit which prevents the burner from cycling if flame is detected or simulated prior to ignition.

For a copy of Bulletin CH4751, write Combustion Control Corporation, 77 Broadway, Cambridge 42, Mass., referring to PETROLEUM REFINER item **139.**

Liquid Level Gauge

The new "Trulevel" gauge, manufactured by Jerguson Gage and Valve Company, "brings the accurate reading of boiler water levels down to easy-reading level at any convenient position remote from the boiler drum." Features of the instrument, how it works and a schematic digram are presented in a new company bulletin.

For a copy of the bulletin write Jerguson Gage and Valve Company, 80 Fellsway, Somerville 45, Mass., referring to PETROLEUM REFINER item **140.**

Industry Equipment

Black, Sivalls and Bryson, Inc., have prepared a condensed general catalog of all its oil industry equipment. Construction features, advantages, capacities and specifications are given for the different types of equipment.

For a copy of the catalog write Black, Sivalls and Bryson, Inc., 720 Delaware, Kansas City 6, Mo., referring to PETROLEUM REFINER item **141.**

Stainless Steel Welding

The Lincoln Electric Company in Bulletin 463 gives the application, properties of the deposited metal, procedure and typical applications for welding stainless steel products with illustrations of each product. Also included are a list of recommended books on arc welding and other welding aids.

For a copy write The Lincoln Electric Company, Cleveland 1, Ohio, referring to PETROLEUM REFINER item **142.**

Welding Fittings

Globe Steel Tubes Company's line of precision process welding fittings are described in its new catalog. Dimensional tolerances for seamless steel butt-welding fittings and advantages of their use are listed.

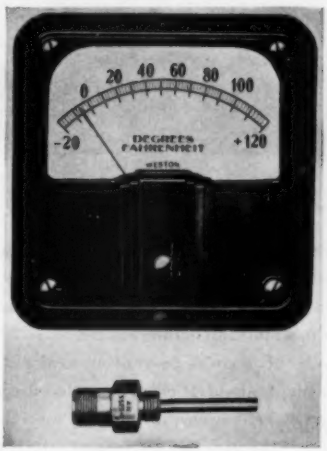
For a copy write Globe Steel Tubes Company, 3839 West Burnham, Milwaukee, Wis., referring to PETROLEUM REFINER item **143.**

Combination Blast Gun

A blast gun, the "Enpro" manufactured by Engineered Products, Inc., combines the features of sand blasting and solvent spraying. The gun is portable and is designed for sand blast operations, or spraying solvents and liquids. The nozzle is changes by loosening a retaining nut and slipping another nozzle in place. Maximum air consumption of the gun is 9½ cubic feet per minute at 100 to 150 pounds pressure. Attachments include an "Abrading" case-hardened nozzle for use in blast operations and a "Solvent" nozzle for use with oils or chemicals. The abrading nozzle has a safety tip that it is claimed will show wear when the barrel needs replacing. The gun is equipped with a three-pint container designed for quick, sure locking with a quarter turn.

Additional information may be obtained from Engineered Products, Inc., 1224 Speer Boulevard, Denver, Colo., referring to PETROLEUM REFINER item **144.**

Electrical Thermometer



A new electrical thermometer, designed particularly for industrial applications where remote indications are necessary, announced by Weston Electrical Instrument Corporation, employs a sensing element known as a resistor bulb, which is placed in tanks, machines, etc., with the direct indicating instrument mounted any reasonable distance from the bulb. With the incorporation of a selector switch and multiple bulbs, "a number of temperature measurements are possible while using but one indicating instrument." It is designed for use on 100-130 volts, 50-60 cycles, a.c. and "is not affected by normal line voltage variation." It can also be supplied for use on d.c.

For further information write Weston Electrical Instrument Corporation, 617 Frelinghuysen Avenue, Newark 5, N. J., referring to PETROLEUM REFINER item **145.**

Prolonging Pump Life

How the selection of materials for the construction of pump and pump parts can add to the life of such units is told in a new booklet published by The International Nickel Company, Inc. Factors discussed are corrosion, corrosion-fatigue, erosion and wear. Case histories are cited in connection with exposure to such destructive influences as sewage, brackish harbor water, sour crude petroleum, marine growth, high pressures and grit, as well as combinations of these influences.

For a copy of the booklet write The International Nickel Company, Inc., 67 Wall Street, New York 5, referring to PETROLEUM REFINER item **146.**

Maintenance Cleaning

The Du Bois Company's brochure on maintenance cleaning for the oil industry features sludge removal from oil lines, heat exchangers and similar equipment by circulation of an Actusol solution. Actusol is a "highly concentrated, emulsifiable oil detergent used for removal of oil sludges diluted with from four to eight parts of a suitable distillate. This solution rapidly disintegrates and suspends sludges permitting them to be flushed from the system." Other subjects covered are the cleaning of storage tanks, tank cars, valves, lubricators, etc., paint stripping, steam cleaning and similar operations.

For a copy of this brochure write The Du Bois Company, Cincinnati 3, Ohio, referring to PETROLEUM REFINER item **147.**

Measuring Appearance Instruments

"Instruments for Measuring Appearance and Other Optical Factors," bulletin issued by Henry A. Gardner Laboratory, Inc., describes four new type instruments for measuring appearance. A fifth instrument, multipurpose Reflectometetr Type M, is also included in the bulletin.

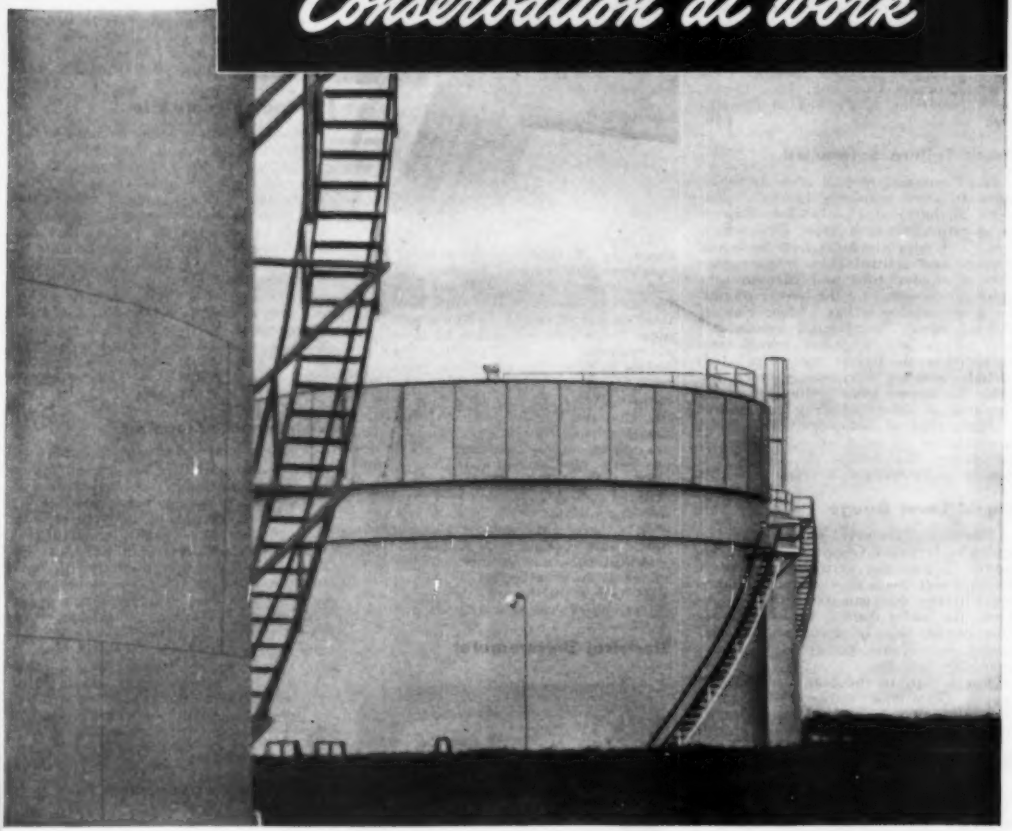
For a copy of the bulletin write Henry A. Gardner Laboratory, Inc., 4723 Elm Street, Bethesda 14, Md., referring to PETROLEUM REFINER item **148.**

Safety Paint Colors

Pratt Paint and Varnish Company has recently added the American Association of Oil Well Drilling Contractors color code recommended safety colors to its new line of paint products made especially for oil industry use. Over a 100 special products in the line were "scientifically formulated and tested to meet the particular paint and protection requirements of the oil industry." The line of products is also labeled with instructions for the specific uses for each one.

For a copy of "Oil Industry Paint Products," write Pratt Paint and Varnish Company, P. O. Box 1134, Dallas, Texas, referring to PETROLEUM REFINER item **150.**

Conservation at work



THE EXPANSION ROOF STOPS VAPOR LOSSES

Elimination of vapor losses . . . conservation through the use of Expansion Roof Tanks . . . has proved its value to producers, refiners and marketers alike, both in preventing the loss of salable product and in maintaining octane rating.

The Expansion Roof permits no venting to the atmosphere and no intake of moisture-laden air. Instead, it rises to accommodate expanding vapors, lowers as the pressure decreases. Perfectly suited to either single or multiple tank installations (through manifolding), the Expansion Roof results in direct dollar savings wherever petroleum products are stored. Call Graver today. Find out just what the installation of Graver conservation equipment will mean to you in terms of marketable product saved.

FABRICATED PLATE DIVISION

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA

New York Philadelphia Chicago Catasauqua, Pa. Houston Sand Springs, Okla.

About EQUIPMENT and SERVICE Suppliers

Clyde Lynde Appointed Head Eagle-Picher Insulation Group

Clyde B. Lynde has been appointed vice president and general manager of the Insulation Division of The Eagle-Picher Sales Company. He will be located in Cincinnati.

Lynde

From United Iron Works, Inc. Lynde came to Eagle-Picher in 1933. He became Joplin insulation district manager and head of the insulation contracting department of the company. In 1943 he resigned to go into the insulation contracting business for himself, organizing Industrial Insulators, Inc., which distributed and applied Eagle-Picher insulations in the Houston area.

During the war he was active in the construction of several high-octane gasoline refineries, synthetic rubber plants and chemical process plants.

Research Laboratory Planned By Mine Safety Appliance

A modern research laboratory, "the largest in the world devoted exclusively to the development of safety equipment for mines," will be built by Mine Safety Appliances Company in Pittsburgh. Construction, to start immediately, is due for completion in September, 1949.

To be known as the John T. Ryan Memorial Laboratory, it will be dedicated as a memorial to John T. Ryan who, with George H. Deike, president, founded Mine Safety Appliances 35 years ago.

Facilities of the laboratory will be available to all industry for the investigation of safety equipment problems affecting health and property. Activities will be coordinated with those of the U. S. Bureau of Mines, U. S. Public Health Service, Industrial Hygiene Foundation of Mellon Institute, Harvard School of Public Health, the new School of Public Health at the University of Pittsburgh and fellowships at other leading universities, officials declared.

Rockwell Managers Hold Meeting

A three-day conference, bringing together all division managers of Rockwell Manufacturing Company, was held February 21-23 in Pittsburgh. The meeting's theme encompassed plant operating statements and annual budgets as tools of operating management.

Thirty members of the firm attended, including: W. F. Rockwell, chairman of the board; W. F. Rockwell, Jr., president; L. A. Dixon; A. J. Kerr; J. E. Ashman; W. H. Newbaker; E. W. Meyers; W. S. Potter; C. A. Wiken; M. J. Carl; C. S. Bygate; W. H. Marsh; E. F. Foubert; H. C. Greene; Munroe Corbin; R. G. Caouette and S. W. Brown of Pittsburgh; A. R. Whittaker, National Meter, Brooklyn; H. F. Zorn, V and O Press, Hudson, N. Y.; W. R. Brown, Arcade Manufacturing, Freeport, Ill.; R. C. DuBrucq, Crescent Machine, Leetonia, Ohio; F. V. Snodgrass, Nordstrom Valve, Oakland, Calif.; H. C. Stuckeman and R. P. Melius, Delta Manufacturing, Milwaukee; W. F. Crawford and W. A. Marsteller, Edward Valves, East Chicago, Indiana; H. S. Rockwell, Hopewell Division, Hopewell, N. J.; H. F. Sacknus, Red Star Products, Norwalk, Ohio; L. W. Heavner, Macnick Division, Tulsa; L. A. Dixon, Jr., Pittsburgh DuBois, DuBois, Pa.

CONTROL

SCALE AND CORROSION

in

Cooling Towers
Compressors and
Engine Jackets

Recently developed applications of the newer colloids and surface-active agents in Wright Chemicals for the petroleum industry result in *improved* water conditioning—*positive* scale and corrosion control. Wright Chemicals contain 100% soluble, available chemicals—no waste or inert matter—insuring increased operating efficiency and reduced cost.

Wright improved chemicals are the result of intensive study and research by men with years of experience in the development, production, application and control of water-conditioning chemicals.

Wright has no one cure-all to solve all problems. Each receives individual treatment. The Wright field engineer, who will call on you upon request, will obtain all necessary information and samples for examination in the modern Wright laboratory. Analyses are interpreted in view of supplemental information received, and recommendations made in the form of a proposal. Clients are provided with regular laboratory service as a periodic check upon conditions.

There is a Wright Field Engineer near you, anxious to help solve your scale and corrosion problems. No obligation.

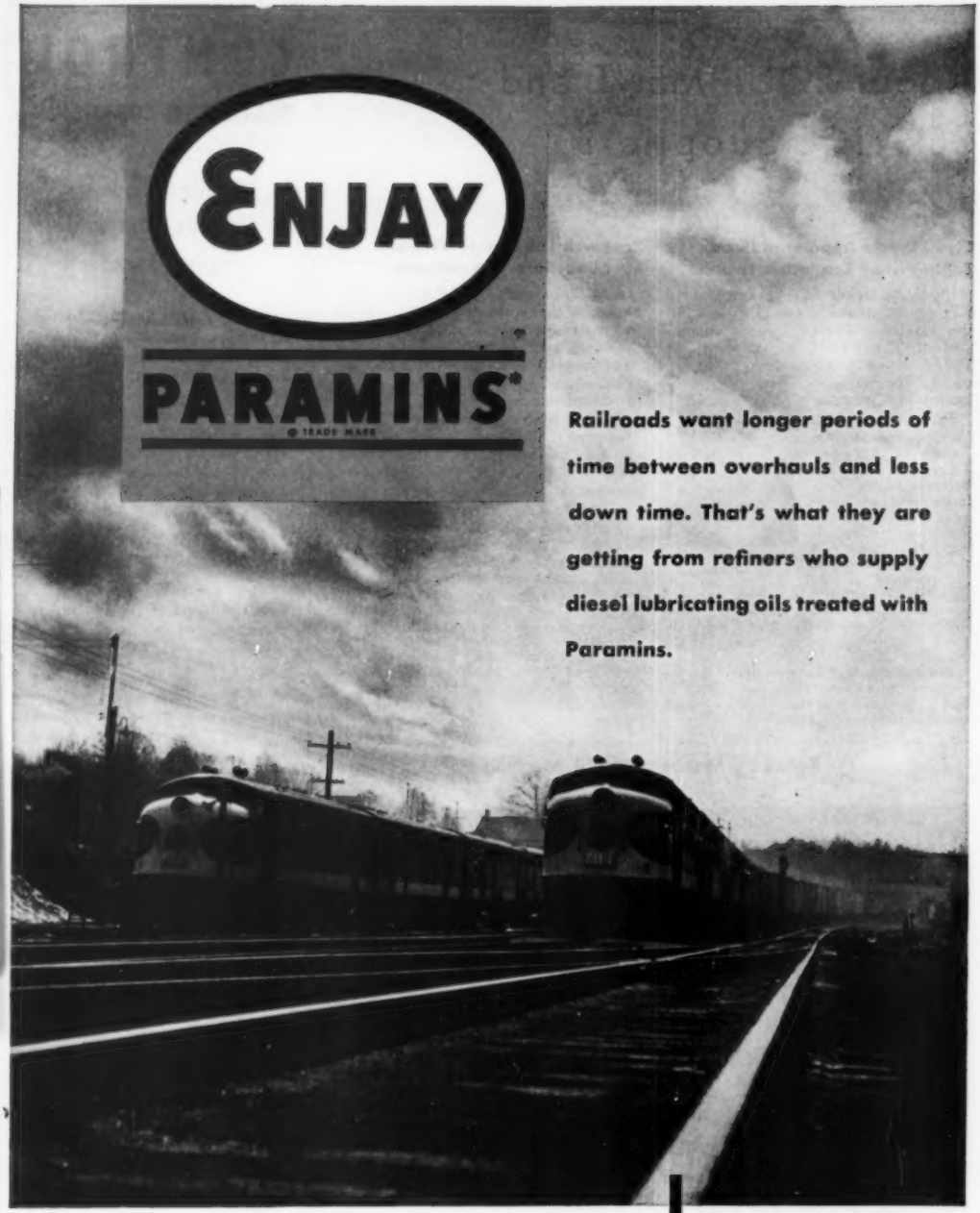
Send for new Bulletin giving full information on Wright chemicals and their applications.

Wright CHEMICALS

WRIGHT CHEMICAL CORPORATION

Specializing in Water Conditioning

GENERAL OFFICE AND LABORATORIES
615 West Lake Street Chicago 6, Ill.
Offices in Principal Cities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PARAMINS®
® TRADE MARK
Railroads want longer periods of time between overhauls and less down time. That's what they are getting from refiners who supply diesel lubricating oils treated with Paramins.

PARAMINS make good oils and fuels better!

PARATONE —for improved viscosity index. PARAFLOW —for lower stable pour. PARATAC —for tacky oils and greases. PARAPOID —for E. P. gear oils. PARANOX —for inhibiting corrosion and oxidation. PARASHEEN —for better appearance. PARADYNE —for improved gasoline.

ENJAY COMPANY, INC.
15 West 51st Street
New York 19, New York

LEADERS IN PETROLEUM CHEMISTRY—MAKERS OF ADDITIVES: ALCOHOLS: NITRILE AND BUTYL RUBBER: CHEMICALS

Grove Regulator Names Four For New Factory Branch

Grove Regulator Company has announced four appointments for its new

Hicks Brown Witt

McMenemy

factory branch located at 3608 Navigation Boulevard, Houston. E. H. McMenemy, retired naval captain and graduate engineer of the U. S. Naval Academy, has been named district manager.

J. D. Hicks will head the distributor sales. H. A. Brown will become a member of the company's field sales force. He will work directly under the Houston office but will have his headquarters in Tulsa, serving the Oklahoma and West Texas area. R. W. Witt has been appointed to the technical sales staff of the Houston branch. He is transferring from the Grove factory at Oakland, Calif.

Personnel Changes Listed By Bailey Meter Company

Bailey Meter Company, Cleveland, Ohio, has expanded its staff of field engineers to include 11 graduates of its special training program. The program consists of a study of principles of combustion and the theory and practice of measurements and control as applied to power and process problems. Factory training in assembly and calibration of the company's meters and controls is combined with lectures by company engineers and factory specialists.

New appointments include:

R. E. Byers to the St. Louis office; N. P. Campbell to San Francisco; G. F. Fitzpatrick to Denver; R. A. Homan to Pittsburgh; T. A. Melton to Charlotte; W. G. Thiemann to New York; J. F. Kontz to Cleveland; G. H. West to Atlanta; N. S. Wilson to Philadelphia; M. G. Johnson to Houston and R. P. Marche to Chicago.

R. E. Ellis and W. H. Robbins have been assigned to the engineering department, R. E. Hartman and R. E. Paulson to the sales department, A. L. Wade to the patent department and F. S. Holby to the research department.

Henry Moore Elected Director

Henry S. Moore has been appointed director of engineering and development for the Consolidated-Ashcroft-Hancock Divisions of Manning, Maxwell and Moore. A 1935 graduate of the University of Arizona, he became associated with the company in 1938. He served in the Army Air Force Engineering Corps in Africa, India and Persia and was discharged as a captain in November, 1945.

YARWAY
IRON
Easy
TO SERVICE
• A good strainer protects your equipment and pipelines.
Maintenance men said "give us a strainer with a blow-off cap that comes out easily and makes up tight; a screen that can be put back in place without a lot of fiddling around".
• The easy-to-remove Yarway cap meets these requirements. It has straight (not tapered) thread, machined face and spark-plug-type gasket. Permits easy removal for cleaning. Insures proper screen alignment when replaced in body.
• Screen itself is of high grade woven monel wire, or perforated if desired.
• Body of strainer is iron or steel, cadmium-plated for protection against corrosion and for better appearance.
• Available in six sizes, ½" to 2", for pressures to 600 lbs. Reasonably priced. Hundreds of thousands in use. Stocked and sold by 150 Mill Supply Houses.
• See your dealer or write for Bulletin S-201.
YARNALL-WARING COMPANY
128 Mermaid Ave. Philadelphia 18, Pa.
YARWAY STRAINERS
"Police the Pipelines"

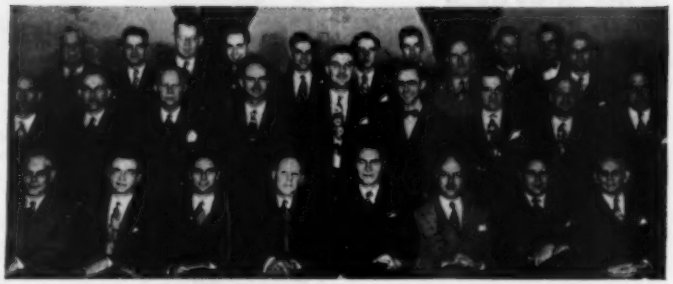
G. E. Establishes Facilities For Western States Area

Expanded repair, maintenance and warehousing facilities for the states of Utah, Idaho, Montana and Nevada will be established in Salt Lake City at a cost of $500,000 by the apparatus department of General Electric Company.

The new facilities coupled with those opened in Denver, Colo. in 1946 will give the Rocky Mountain area "one of the most up-to-date G. E. service organizations in the country." G. E. has 29 such installations throughout the U. S.

The Salt Lake City service facilities will be housed in a new service shop and warehouse building, scheduled for construction this spring and planned to be completed by late summer.

Oster Manufacturing Sales Clinic



The Oster Manufacturing Company, Cleveland, Ohio, recently conducted a four day sales clinic, a photograph of the group appearing above. Roger Tewksbury, president, opened the clinic with an appraisal of general business conditions. Art Gould, vice president, presented Oster's 1949 sales plan, calculated to meet the conditions expected in the accelerating transition from a sellers' to a buyers' market. Sales representatives of the company demonstrated new and improved Oster products. A banquet closed the clinic.

ORIGINATORS OF BALANCED LOADING EQUIPMENT

SPEED and VOLUME-LOADING are ASSURED with OILCO'S DOUBLE-FEED SWING JOINT

ENGINEERED and PATENTED by

OILCO

Pat. No. 2073255

MODEL 600-D DOME-TYPE TANK TRUCK LOADING ASSEMBLY WITH MODEL 620 DOUBLE-FEED SWING JOINT

SIZES, 3" and 4"

The loading of gasoline and oils is made easier and more speedily with the Oilco 620 Double-Feed Swing Joint; made only by and patented by Oil Equipment Mfg. Co., Louisville.

Yes, high-speed loading without choking, nor leaking, and incorporating Oilco Model 150 loading line valve which withstands 300 degrees of oil heat.

Illustration shows double fork feeding into fulcrum arm from both sides.

Long service and steadiness is assured, and uneven wear on bearings is prevented by two support bearings. Five rings of heat-resistant gasoline packing prevent leakage. Weight on the swing rests on the outboard bearings and the joint itself does not rest on the packing. Swings at all angles.

The tank truck loader shown, Model 600-D, meets every loading demand of the industry. The bronze angle swing joint swings in 360-degree radius, permitting dip pipe to enter dome from any angle, with handle on the joint to enable operator to adjust sliding sleeve to desired position. Counter-balanced weights allow the loader to remain in an upright position when not in use. Vacuum control completely drains the assembly upon raising it from truck.

Complete descriptions in Oilco catalog No. 500.

OIL EQUIPMENT MFG. CO., INC.
3100 VERMONT AVE., LOUISVILLE 11, KY.
Canada: Empire Brass Co., Ltd., London, Ont.

Three New Branch Offices Are Announced by Foxboro

The Foxboro Company, Foxboro, Mass., has opened a new branch office at 123 West College Avenue, Appleton, Wis. The manager is Milton A. Schreiner, an instrument engineer associated with the company since 1922.

Another new office is at 6225 Brookside Avenue, Kansas City 2, Mo., where George J. Willier is manager. He joined Foxboro in 1944.

At Baton Rouge, La., John B. Deaderick is manager of the office recently opened at 115 North 19th Street.

Foxboro resident engineers have recently been headquartered in two other cities: Eugene F. Machell at 209 North 79th Street, Milwaukee 13, and Russell E. Steward at Frankfort, N. Y.

Carrier Corporation Plant Awarded High 1948 Rating

Carrier Corporation, Syracuse, N. Y., was named "Minute Plant of 1948" by the Society for Advancement of Management, at its recent national conference in Chicago. The award was made in recognition of Carrier's contributions to national security last year. George R. Auld, vice president of the manufacturing division, accepted the award for Carrier.

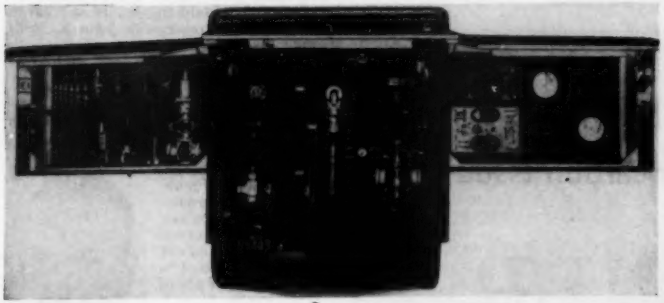
"A Minute Plant," said Thomas Sullivan, conference chairman who announced the award, "is an industrial plant that has taken planning steps so that the company is prepared to make a switch-over to defense production quickly and efficiently to meet the needs of national defense."

The judging was based on a 139 point check list covering all phases of plant preparedness.

Wright-Austin Moves

Wright-Austin Manufacturing Company has moved its offices and plant from 315 West Woodbridge Street to 3245 Wight Street, Detroit 7, Michigan.

"Demonstrator" Takes to Highway



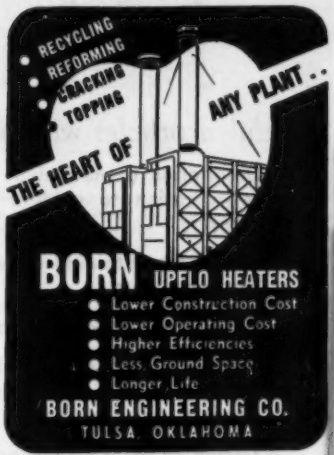
Mason-Neilan Demonstrator To Visit Various Sections

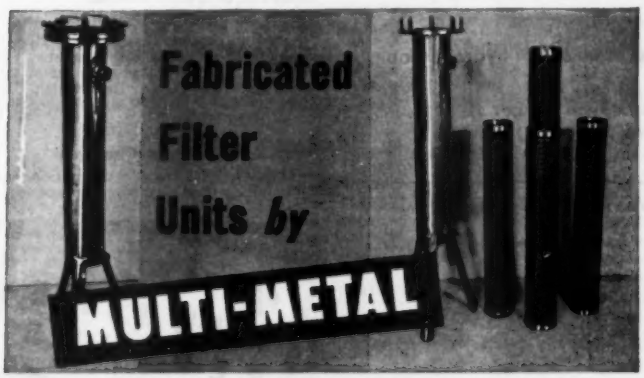
A new Mason-Neilan Regulator Company demonstrator, built so that instrument engineers and operating personnel might see a cross-section of the latest developments in the company's control equipment, is on tour through the Southern states. From there it will proceed to the Southwestern and Pacific Coast states, returning east via the Rocky Mountain and Central states and terminating the tour in New England.

An air compressor is an integral part of the demonstrator, permitting much of the equipment to be in actual operation. Cut-away models are used. The demonstrator is constructed with two side panels which swing out to a right angle, position and together with the rear section, form a display some 20 feet wide. Fluorescent lighting is used.

Houlihan Redgrave

The field demonstrator will illustrate Mason-Neilan pressure regulating valves, air-operated diaphragm control valves, etc. Of particular interest is the display of a displacement type level controller with transparent calibrated displacer chamber. New developments being shown are a pressure controller for valve or wall mounting which features leaf spring-pneumatic feedback for exact linear proportionality; a level switch, torque tube actuated, with explosion-proof micro-switches for two-position level indication; a level controller with separate pneumatic transmission mechanism; a level pilot for adaptation to problems requiring level measurement by ball float; and a control valve positioner and motion transmitter. Included also are large size charts detailing air





A leading plant in the East brought us their filtering problem. The result: a custom-designed stainless steel filter with four especially designed interchangeable units.

Fabricating filter units of wire and cloth has been our "specialty" for over 35 years. Multi-Metal is equipped to handle the entire operation from wire cloth to final fabrication and assembling. On your next job we invite you to submit your requirements. Let us show you how our fabricating service can offer you short cuts to operating efficiency as well as economies through completely integrated fabrication — all within one plant.

More than 35 years of service to process industries

Multi-Metal
WIRE CLOTH COMPANY, INC.
1350 Garrison Ave., New York 59, N. Y.

ESPECIALLY RECOMMENDED FOR USE IN THE

COPPER SWEETENING PROCESS

Nichols
TRIANGLE BRAND
COPPER SULPHATE

is preferred by leading refineries because of its high copper content, dependable uniformity and exceptional purity and freedom from foreign and inert matter.

99% + PURE

Quotations on request, on any quantity required. Shipments can be made from our nearest plant.

PHELPS DODGE REFINING CORP.
40 WALL STREET, NEW YORK
230 N. MICH. AVE., CHICAGO

Coming

MAY 10th

The Light Hydrocarbon Issue

PETROLEUM REFINER

Scheduled articles will give you . . .

- **Description of new plant employing low temperature refrigeration to achieve increased natural gasoline recovery**
- **Means for obtaining increased propane recovery from existing plants**
- **Calculation of demethanizers**
- **Description of new and efficient gasoline plant which was assembled almost entirely from salvaged components**
- **Design of thick-walled pressure vessels (cycling plant absorbers)**
- **Thermochemical calculations for light hydrocarbon plants**

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circuits of the various controllers, permitting complete discussion of operating principles.

James J. Houlihan, Jr., is in charge of the demonstrator with John R. Redgrave his assistant.

H. Belfield Acquired By Minneapolis-Honeywell

Minneapolis-Honeywell Regulator Company has entered an agreement for the acquisition of the assets of the H. Belfield Company, manufacturer of automatic control valves.

Murray

Howard L. Murray, president of Belfield, has been elected a vice president of Minneapolis-Honeywell and will be in charge of the new acquisition which will be known as the Belfield Valve Division of Minneapolis-Honeywell. Other personnel will be retained.

Products of the division will be distributed nationally through Honeywell branch offices in this country and abroad through its foreign subsidiaries. The new acquisition "will enable Honeywell to supply its own control valves for application in connection with the industrial controlling instruments of the type made by the company and its Brown Instruments division." The valves made by Belfield will also be applied to the automatic control systems made by Honeywell for use in heating and air conditioning installations.

Quentin Graham Elected Elliott Company Executive

Quentin Graham has been elected a vice president of Elliott Company. He joined Elliott in 1944 as manager of the electrical engineering department. In 1946, he was appointed manager of the Ridgway division.

Mathieson Makes Changes

Mathieson Chemical Corporation has announced three recent changes in per-

QUICK TURBINE REPAIRS

If you need dependable Turbine repairs *in a hurry*, call us. We are completely equipped to repair and dynamically balance turbine rotors and any High Speed rotating elements in our modern shops.

25 Years of Successful Experience

GULF ENGINEERING CO., INC.

Service Not Promises

1092 INGEBORG ST. HOUSTON, TEXAS

916 S. PETERS STREET NEW ORLEANS, LA.

sonnel. Roland F. Boehm, district sales manager, Houston, has been transferred to the ammonia department, with New York headquarters; O. J. Theobald, Jr., district sales manager, Charlotte, N. C., replaces Boehm as district sales manager, Houston; and J. F. Carey, sales representative in the Charlotte territory, has been named district sales manager of the Charlotte office.

Bryce Curry Is Specialist for Hancock Valves In Gulf Area

Bryce B. Curry has been engaged as a field specialist for Hancock Valves, manufactured by Manning, Maxwell and Moore, Inc., Watertown, Mass. Headquarters will be in the Houston district office, and he will cover the Gulf Coast area.

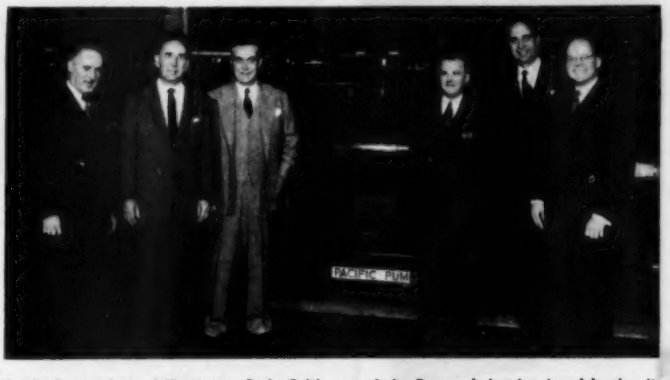
Formerly he was district manager for Jarecki Manufacturing Company and United Supply and Manufacturing Company. Before being appointed to his present position, Curry was field superintendent for Scurlock Oil Company.

Alloy Steel Adds Two

Henry G. Harley and Elliot A. Baines have joined Alloy Steel Products Company, Linden, N. J., as sales representatives and have been assigned to the New York area.

Previously Harley had refinery operating experience at Aruba, South America, and sales engineering experience in the valve industry. A graduate of Middlebury College, Baines was formerly associated with American Brakeshoe Company.

Pacific Pumps Celebrates Anniversary



Pacific Pumps, Inc., of Huntington Park, Calif., one of the Dresser Industries, is celebrating its 25th year of specialized service to industry. Honoring the occasion with a tour of inspection of the Pacific plants and manufacturing facilities are Arthur R. Weis, president of Pacific; William A. McAfee, member of the executive committee of Dresser Industries, Inc.; John B. O'Connor, executive vice president of Dresser; Elmer J. Weis, vice president of Pacific; Prescott S. Bush, member of the executive committee of Dresser; and Neil H. Mallon, president of Dresser.

Southern Acid & Sulphur Is Purchased by Mathieson

Mathieson Chemical Company has contracted to purchase the business and assets of Southern Acid & Sulphur Company, Inc.

Plants of Southern Acid and Sulphur are located at Houston, Beaumont and Port Arthur, Texas; Shreveport, La.; and Little Rock, McKamie and Macedonia, Ark. Net sales of the company totaled $21,800,000 for the twelve months ended December 31, 1948, and resulted in a net profit of approximately $2,620,000.

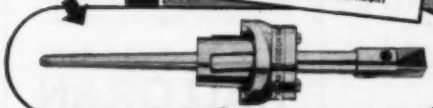
DUDGEON *HIGH EFFICIENCY* TUBE EXPANDERS

..Backed by a reputation for jobs well done!

DUDGEON TYPE 22 An efficient quality tool recommended for all general boiler work. Has a large range of expansion for a variety of tube gauges and sizes. It draws the tubes out of the tube sheet and automatically sets the tube at the proper distance. Tubes are expanded the full length of the tube ends.

Check the reputation of DUDGEON tools on the job—ask the men who uses them! Double check too, what we mean when we say each tool is designed by and for men who know what good tools can do to cut costs and "up" job quality. Do this and you'll find that DUDGEON'S 97 years have been aggressively occupied in advancing designs, improving materials, and modernizing methods so that these expanders deliver maximum efficiency at low cost.

Complete literature on Dudgeon products — expanders, hydraulic pumps and jacks — available. Write Department



RICHARD *Dudgeon* INC.

MFRS. OF TUBE EXPANDERS SINCE 1853

24 COLUMBIA STREET, NEW YORK 2, N. Y.

Continuous Circulation Method Cuts Equipment Cleaning Time 50%!

THAT'S what a Texas operator discovered when he installed a specially engineered Oakite method of cleaning the processing system—absorber, heat exchanger, still, pre-heater. Circulation of a recommended Oakite cleaner, under carefully determined temperatures and pressures, resulted in quick break-up of carbonized deposits, grease films, basic sediment.

If you are interested in less shutdown time and higher output at closer specifications . . . call the Oakite Technical Service Representative near you. Or write for your free copy of the Oakite Petroleum Digest of 88 maintenance cleaning and descaling procedures. Oakite Products, Inc., 50B Thames St., New York 6, N. Y.

Technical Service Representatives Located in Principal Cities of United States and Canada

OAKITE 1909 1949 40th ANNIVERSARY YEAR

OAKITE

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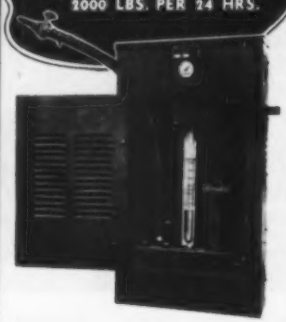
SPECIALIZED INDUSTRIAL CLEANING

MATERIALS • METHODS • SERVICE

Paddock
CHLORINATORS
CAPACITIES UP TO
2000 LBS. PER 24 HRS.



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SLIME CONTROL

Operates on high vacuum — no moving parts. Only 6 ft. installation space. Sturdy cabinet permits outdoor installations. Available in 8 capacities — 15 lbs. to 2000 lbs. of chlorine per 24 hours. Ideal for chlorinating drinking water.

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Lunkenheimer Makes Territorial Changes

Boles Waldeck Davis Tieberman

The Lunkenheimer Company has made changes in its territorial representatives as follows:

Elmer R. Tieberman, who for many years has handled the oil field sales territory embracing Oklahoma and Kansas with headquarters in Tulsa, has transferred to Dallas, covering northeastern Texas, northern Louisiana and part of Arkansas.

Duffie Davis succeeds Tieberman at Tulsa. He formerly worked out of Wichita Falls, Texas, covering West Texas.

William A. Boles recently joined Lunkenheimer and will take over the territory formerly handled by Davis.

Marshall Stickel and Joe Birkhead, representatives in the Mid-Continent and Gulf Coast districts, will maintain their headquarters in Houston.

Joseph Waldeck will confine his activities to parts of Missouri and southeastern Illinois with headquarters in St. Louis, Mo.

Quaker Rubber Company Names Lewis District Head

John R. Lewis has been appointed manager of District 2 for Quaker Rubber Corporation. His territory includes Pennsylvania, Maryland, Delaware, Virginia, Tennessee, North Carolina, South Carolina, Georgia, Florida and Alabama.

Before entering the sales division Lewis was in the manufacturing plant, laboratory, cost and time study division and the merchandising department of Quaker. Previously he was assistant to the general sales manager.

Minneapolis-Honeywell Names O. B. Wilson Sales Manager

O. B. Wilson, eastern regional sales manager for Brown Instruments division of Minneapolis-Honeywell Regulator Company, has been named manager of sales for the east, southeast and central regions.

Wilson, who has been with the industrial instruments division of Honeywell for the past 25 years, will supervise sales in the area extending from Florida and the Gulf of Mexico to the Canadian border. He will make his headquarters in Philadelphia.

Addition for Foxboro

Work has begun on an addition to the building at 5151 Baum Boulevard, Pittsburgh, owned by The Foxboro Company. The new addition, to be occupied in early spring, will be used for the assembling of control valves and for warehousing an increased stock of valves and instruments. A. H. Shafer is district manager.

Marcus Appoints Cook

E. B. Cook Company, 1063 Howard Street, San Francisco, has been appointed territorial representative in northern California for Marcus Transformer Company, Inc., Hillside, N. J.

Help Wanted—Male

Construction Superintendent for supervisory work on refinery and gasoline plant construction; must have minimum of ten years field experience either as construction engineer or construction superintendent and be thoroughly capable of handling large projects. This is a permanent, responsible position and will require an extremely high type of executive; man selected will be thoroughly investigated. Reply in own handwriting, giving full details as to age, education, training, and salary desired. Under experience, name the companies where previously employed, the projects employed on, responsibilities involved and previous salaries as well as name and address of your superiors. Address: Box 136-H, c/o Petroleum Refiner, Houston, Texas.

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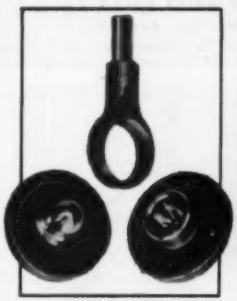

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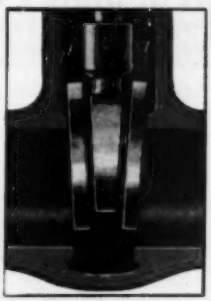
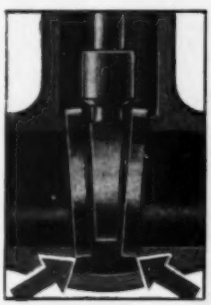
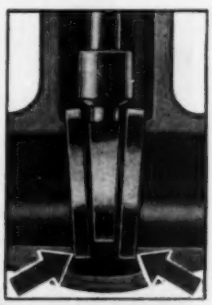


Floating discs can rotate, for even wear on the parts.



Direct acting—stem thrust through wedge rings seals the ports.



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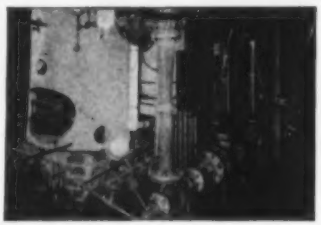

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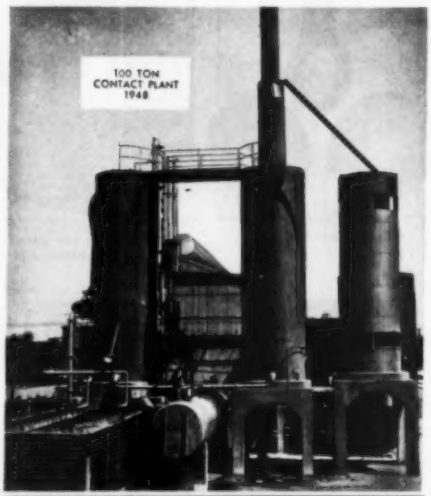

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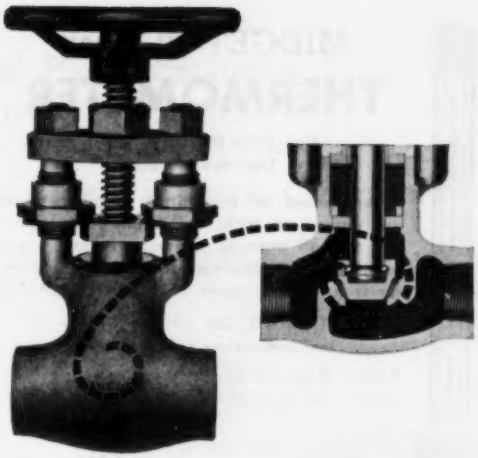

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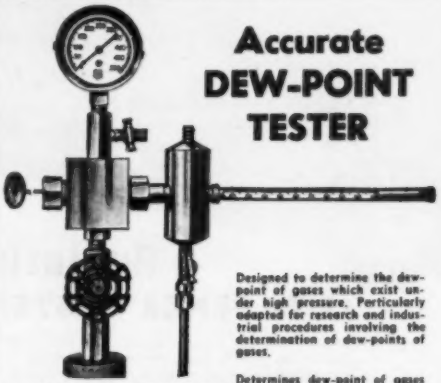

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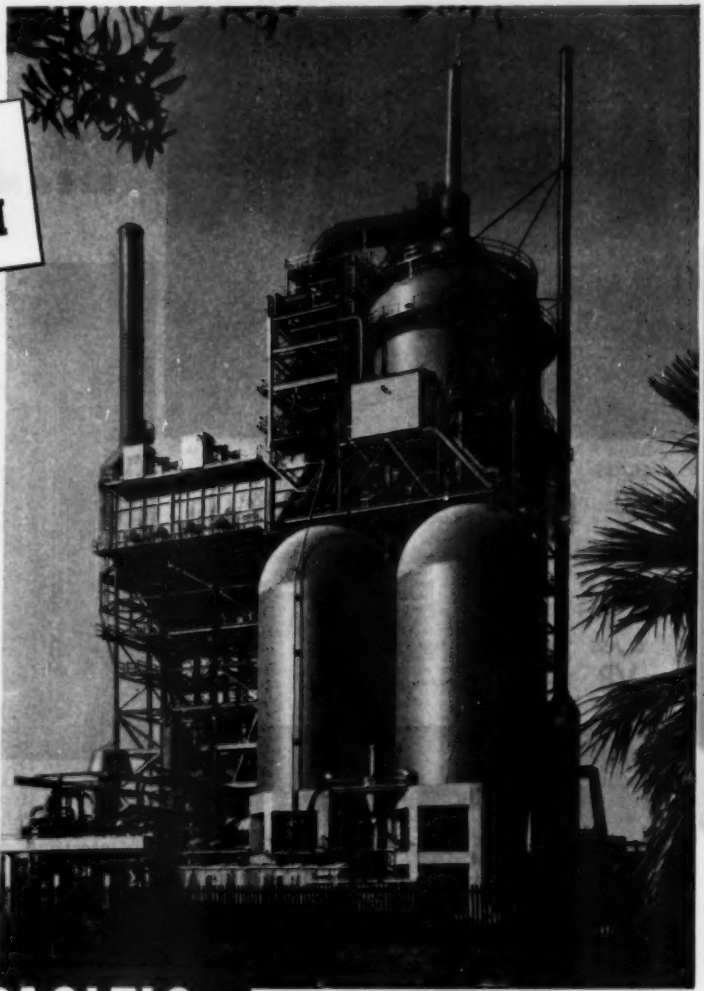

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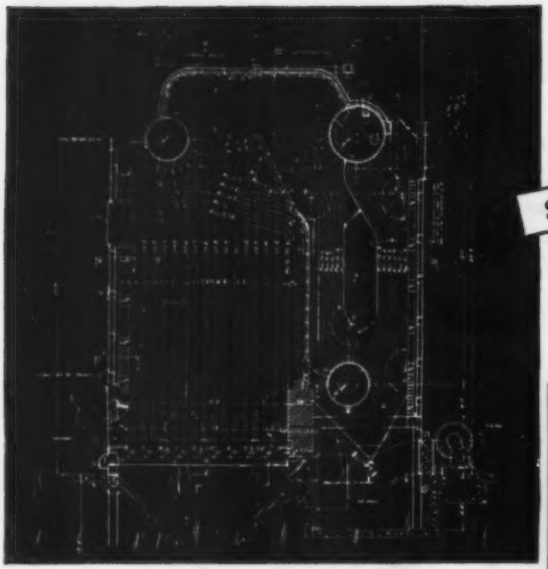

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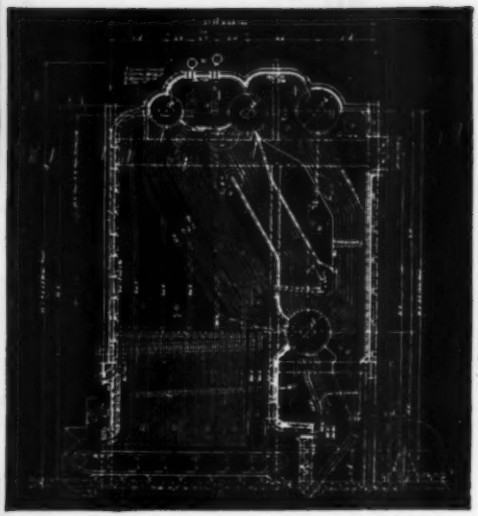

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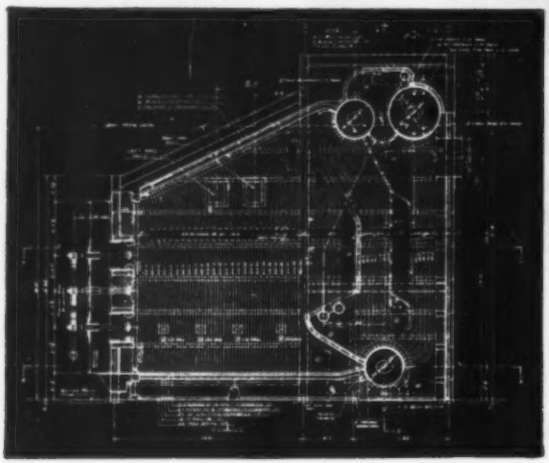

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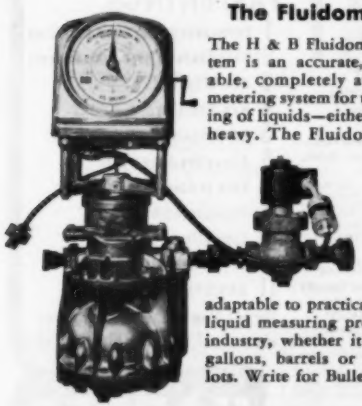

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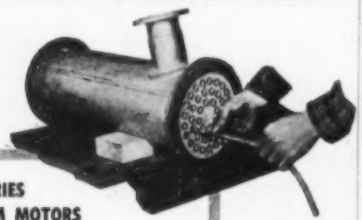

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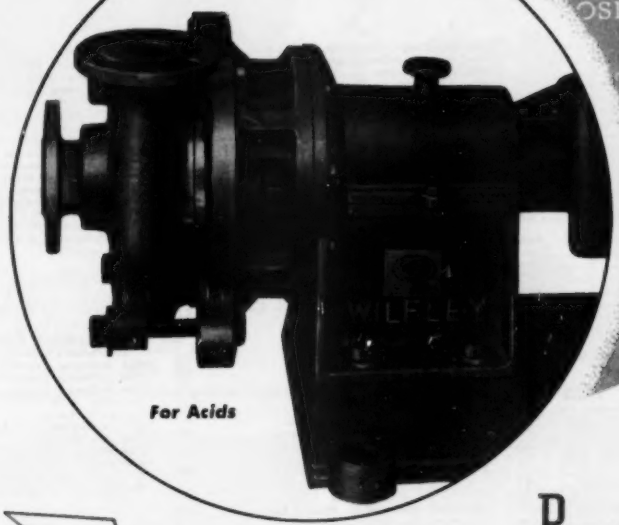

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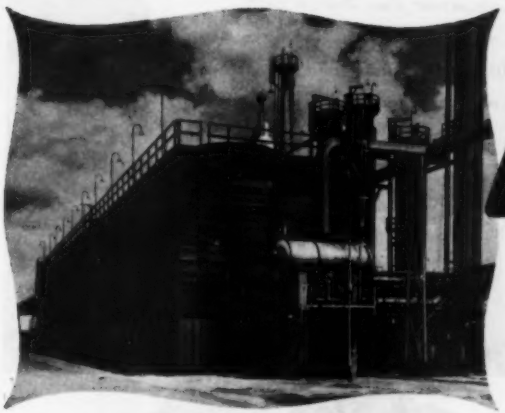

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